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# NINTH ANNUAL ASPHALT PAVING CONFERENCE - 1930

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# ASPHALT PAVING
# CONFERENCE, 1930

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# NINTH ANNUAL ASPHALT PAVING CONFERENCE

[Proceedings]

*Held Under the Auspices of*

## THE ASPHALT INSTITUTE

and

## THE ASSOCIATION OF ASPHALT PAVING TECHNOLOGISTS

December 1-5, 1930

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# FOREWORD

The Ninth Annual Asphalt Paving Conference held in Memphis, Tennessee, December 1 to 5, 1930, was the most successful of all the conferences that, thus far, have been held. The registration numbered six hundred and ten and exceeded that of any of the eight preceding conferences, except the one held in New Orleans in 1928. Of those in attendance, one hundred and twenty were Federal and state highway officials from the United States, or were Provincial highway officials from Canada.

The program of discussions, as presented in five sessions, embodied a series of survey reports, compiled after exhaustive questionnaire surveys and studies had been made by committees of leading engineers. This was a departure from the program at previous conferences. The attendance of the noted aviators, Colonel J. H. Jouett, Major J. H. Doolittle and Captain Frank M. Hawks, gave a very practical turn to the airport paving discussions, while Captain Hawks' record flight of 1,000 miles to Memphis from New York in six hours and fifteen minutes, Major Doolittle's flight of 270 miles from St. Louis in one hour and twenty-nine minutes and Colonel Jouett's flight from New Orleans in approximately two and one-half hours attracted nationwide attention to the meeting and participation in its program by the aviators.

A roster of the presiding officers who so ably guided the proceedings throughout the five sessions is as follows: First session, Leroy M. Law, of St. Louis, president, The Asphalt Institute; Second session, R. H. Baker, state highway commissioner of Tennessee; Third session, M. A. Lyon, chief engineer, Province of Manitoba, Canada; Fourth session; Hugh W. Skidmore, consulting engineer, Chicago, Ill., and Fifth session, Prevost Hubbard of New York, president of the Association of Asphalt Paving Technologists.

The social and entertainment features were unique and enjoyable, being, in fact, among the best that have been presented at any of the conferences. The delightful hospitality of the City of Memphis and the cordial and friendly participation in all the convention social affairs by the city's best people gave everyone in attendance the feeling of being among sincere friends. All returned to their homes with the conviction that their visit to Memphis will be long remembered as a most pleasant occasion. The social features included an informal reception and dance; breakfast, bridge party and theatre party exclusively for the ladies; supper and dance with novel miniature yacht race feature; entertainment at one of the Memphis night clubs; dinner and dance with an especially staged cotton plantation singing and dancing act; golf tournament for the men, and a trip by bus for all the delegates to the Memphis Municipal Airport to witness the arrival of Captain Hawks after his record flight from New York.

Local arrangements in Memphis, including those for the social and entertainment features, were made by committees of which the chairmen were as follows: General Arrangements and Entertainment Committee, W. B. Fowler, city engineer of Memphis; Reception Committee, H. S. Read; Ladies' Entertainment Committee, Mrs. W. B. Fowler; Transportation Committee, E. H. Cannon, and Golf Tournament Committee, C. L. Williss.

LEROY M. LAW
St. Louis, Mo.
President, The Asphalt Institute, 1930

CHARLES A. MULLEN
MONTREAL, CANADA
PRESIDENT, THE ASSOCIATION OF ASPHALT PAVING TECHNOLOGISTS, 1931

NINTH ANNUAL
ASPHALT PAVING CONFERENCE.
PEABODY HOTEL
MEMPHIS TENN.
ROLAND PHOTO

Opening Session, Ninth Annual Asphalt Paving Conference, Peabody Hotel, Memphis, Tenn., December 2, 1930.

NINTH ANNUAL
ASPHALT PAVING CONFERENCE BANQUET.
PEABODY HOTEL
MEMPHIS TENN.
POLAND PHOTO.

Annual Dinner, Followed by Vaudeville and Dancing, Ninth Annual Asphalt Paving Conference, Hotel Peabody, Memphis, Tenn., December 4, 1930

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# Ninth Annual Asphalt Paving Conference

## Memphis, Tennessee, December 1-5, 1930

## OPENING SESSION

### HOTEL PEABODY, 10 A. M., TUESDAY, DECEMBER 2, 1930

### LEROY M. LAW, PRESIDENT, THE ASPHALT INSTITUTE, PRESIDING

President Leroy M. Law of The Asphalt Institute called the conference to order and, after expressing his appreciation of the large attendance and the splendid cooperation manifested in arranging the conference program, introduced Mr. R. H. Baker, state highway commissioner of Tennessee, who delivered an address of welcome on behalf of the Governor of Tennessee, the Hon. Henry H. Horton, and the officials of the State Highway Department. During his address, Mr. Baker extended an invitation to those attending the conference to visit a number of asphalt construction projects in different parts of the state and stated that a number of engineers with cars were present from the State Highway Department to act as guides for such trips as any of the delegates might elect to make. "I appreciate this opportunity of welcoming you", said the Highway Commissioner, "on behalf of the Governor and the State of Tennessee and I wish to express to you the most sincere appreciation of the Tennessee Highway Department for your having selected this state in which to hold your conference."

#### VICE MAYOR STRESSES IMPORTANCE OF EMPLOYMENT.

Acting for the Hon. Watkins Overton, Mayor of Memphis, the Vice Mayor, Mr. Clifford Davis, extended the greetings of the city. "My friends," said Mr. Davis, "we deeply appreciate having you in our city today because we honestly believe that at this time you are among the most important people in the United States. The national government and the state, county and local governments and the people-at-large are expecting the road builders to be of considerable aid during this period of depression. Everywhere they say 'build roads and everybody will be happy.'

"The Federal, state and local governments are saying it and at the same time they have the obligation of raising the money to put into your hands so you can start the road construction. I really think, therefore, that you are among the most important people in the United States today and, whether you really believe it or not, I am going to tell you so, for the world is giving you that sort of credit.

"We are mighty proud of the road building that our state has been doing," Mr. Davis continued. "We are glad that our own city could build the beautiful boulevards and the smooth street pavements that we have. We are mighty happy to have you here. We know that your presence is going to mean far more to us in this section than we can possibly mean to you. With every good wish for a happy, successful and fruitful convention, the City of Memphis bids you a warm and sincere welcome. Ladies and gentlemen, the city is yours."

Greetings were extended also by W. B. Fowler, city engineer of Memphis and chairman of the Local Committee on Arrangements for the Conference, who, in the course of his remarks, invited those in attendance to inspect the asphalt streets of the city, where he said many excellent examples of asphalt construction had been laid.

As the next order of business President Law of The Asphalt Institute delivered the president's annual address.

# President's Annual Address

## By Leroy M. Law, St. Louis, Mo.

***President, The Asphalt Institute***

This occasion of our Ninth Annual Asphalt Paving Conference is one of particular importance, occurring as it does during a rather critical period in our national economic history. It is not only well that we meet here to discuss the problems of our industry, as we have done in our former conferences, but we should consider these problems in their relationship to the national situation, for both opportunities and responsibilities today confront the road builders just as they do all other industries. The opportunities are to insure the utmost measure of relief in the present unemployment situation; to help solve one of the most important phases of our agricultural problem; to point out some of the obstacles which are hampering industry and, by coordinating these efforts, to making business and industry both productive and profitable. The responsibility rests upon us to do these things now and to do them both thoroughly and conscientiously.

### IMPROVEMENT OF FARM-TO-MARKET ROADS.

Highway construction is already a major industry, involving as it does an annual outlay of not less than $1,500,000,000. Some estimates, in fact, run as high as $1,750,000,000, but, regardless of the exact figure, there are no conceivable appropriations of public money fundamentally so helpful under present conditions as are our highway budgets. The soundness of this assertion is established when we consider that between 50 and 60 percent of the total outlay for road building goes directly to the payment of construction wages, while another 20 or 25 percent goes to the payment of wages at refineries, quarries and other sources of road building material. The acceleration of highway construction during the season just closing has, therefore, extended its benefits beyond the confines of the states or municipalities directly concerned. Our paving tonnages will probably exceed those of 1929 and, as a result, we have maintained our organizations and perhaps contributed more than usual to other industries through the extension and modernization of our equipment.

In referring to the important phase of our agricultural problem, I had in mind the necessity of providing low cost roads for the vast majority of our farmers who are without the advantages of all-the-year-round transportation. Perhaps no national question of an economic character has received so much attention and aroused so much enthusiasm as has this movement to build these so-called farm-to-market roads. Without going into statistics bearing on the question, let me say that you can build about eight miles of average low cost asphaltic roads at the cost of a single mile of the expensive high types now being provided in our major system. Not only this, but the building of these local roads, by utilizing local materials which are usually close at hand and which may constitute from 90 to 95 percent of the total mass of pavement, circulates money among the people who, through its use, quickly increase the purchasing power of their community and thus that of the nation. Certainly there is no activity which can help the people of this country to greater advantage than by expediting this farm-to-market road program.

Let me say at this point, however, that no one should be misled as to what constitutes a low cost, all-the-year-round highway. It does not involve simply the makeshift of filling up the mud holes and of dragging material back from ditches to the center of the highway, nor does it mean the building of narrow strips of pavement at high unit cost with the idea that the farmer's road problem is being solved. It means actually the assurance of hard, durable roads with remarkably smooth-riding and non-skid surfaces and at such low unit costs that ample widths are also possible with modest expenditures.

### Relation of Roads to Automobile Markets.

Unfortunately much highway building has been that of simply stretching dollars into miles, and without due regard to the other factors, so that many of our roads constitute veritable death traps. What the country needs, therefore, is not only more miles of paved roads but roads of adequate width so that the motorist can travel over them rapidly and with some assurance of comfort and safety. Asphalt, through its various types and forms of application, lends itself admirably to such a program.

The intimate manner in which road building is linked up with other major industries is shown in a startling manner when we consider its fundamental relationship to the automobile and petroleum industries. Already manufacturers of motor cars are realizing that they cannot reach their potential expansion without a considerable expansion of our present systems of paved highways, and without more automobiles the petroleum industry cannot expect soon to solve its present problems occasioned by over production of motor fuels and lubricants. The automobile thus is the center of a great economic system, especially so since the roads on which it travels are largely built from taxes on the fuel which it consumes. It might be argued from this relationship that we cannot build more roads without further taxing gasoline, but the automobile long ago passed from a luxury to a necessity and the limits to which necessities can be taxed have about been reached in the case of this vehicle. We can, and should, however, devote all of these gasoline taxes to highway purposes, selecting such types of construction as will assure the greatest immediate benefit consistent with the actual traffic requirements and the factor of safety already referred to.

### NEED OF RELIEF FROM RUINOUS TRADE PRACTICES.

It is appropriate, perhaps, at this meeting, to repeat what has been said over and over again by other association representatives, namely, that there should be some relief from present governmental restrictions as to the handling of the common problems of an industry. In spite of the present healthy demand for asphalt in its various forms, there is also over production in our industry and this is rapidly bringing us to the door of a ruinous price competition. Not only this but it has already led to unwholesome trade practices which in the end will benefit neither the refiner nor the consumer of our products.

Some of us have been under the impression that we could have eliminated these abuses through joint agreement but as trade practices are so intimately associated with the price structure, our optimism is lost in the fear that we may find ourselves in conflict with the Federal statutes.

BITUMINOUS PENETRATION HIGHWAY IN TENNESSEE, U. S. ROUTE NO. 6, BETWEEN GREENVILLE AND JOHNSON CITY. PHOTOGRAPHED IN 1922.

The asphalt industry has no desire to hamper a healthful price competition but it does believe that there should be some avenue of relief from a ruinous competition made more unfortunate by some of the present trade practices. Industry can only serve as it prospers and I trust that our Federal authorities will soon give to this matter the very careful consideration which it deserves.

Although this conference is devoted primarily to the subject of paving and highway matters, our meeting in this great Mississippi River metropolis brings to attention the great problem of flood control along the Mississippi and its tributaries. Asphalt, it is true, thus far has not been used extensively for the protection of river banks and levees, but one of its first uses was that of a waterproofing and preservative medium. It can, however, be produced in such a wide variety of types embodying various combinations of physical and chemical properties, and it lends itself to so many methods of application, that it well merits the serious consideration of engineers directly concerned with this flood problem. As Nebuchadnezzar, over 2,000 years ago, found it expedient to combine asphalt with other materials in order to keep out the flood waters of the Euphrates, may we not, with our modern engineering skill and experience, be able to develop some combination or form of this useful production that will afford protection against the floods of the Mississippi? Personally, I believe the problem is one which can be solved through joint research by engineers and asphalt technologists and a method can be devised which will make possible the necessarily vast construction work at a moderate cost.

## RESEARCH IN HIGHWAY DEVELOPMENT.

The Asphalt Institute is the official organization of the asphalt producers of the United States. It represents the industry in the conduct of important research investigations, in the simplification of grades and specifications and in the dissemination of information and advice as to the intelligent use of asphalt. It has made substantial progress during the past year in its cooperative work with those Federal, state and municipal agencies which have sought its assistance and if you engineers, public officials, technologists and contractors will bring your problems to The Asphalt Institute, you will thereby be helping it to fulfill the purposes for which it was established. It is gratifying to note that, in spite of a large falling off in the demand for roofing asphalts this year, the demand in connection with street and highway materials is far ahead of that of last year, so that from the present outlook the tonnage for 1930 will probably equal, if not be in excess of that for 1929 which was the record year for our industry. Furthermore, all indications point to an increased demand and a wider application in the uses of asphalts for the coming year.

## TECHNICAL PARTICIPATION IN THE CONFERENCE.

But I must get down to the program which has been prepared for you. We meet again this year in company with the Association of Asphalt Paving Technologists, that growing organization of technical men who are giving their attention to the scientific aspect of asphalt paving with a view to guiding us in the selection of suitable materials and their correct combination and manipulation. Considering the magnitude of their problem, they have made commendable progress in dispelling the mysteries which formerly surrounded asphalt paving and in substituting scientific methods for the old rule-of-thumb practices. But the president of the Association of Asphalt Paving Technologists is here and he can tell you best of the accomplishments. The technologists are contributing one complete session of this program and you will find their papers of timely interest.

An innovation which you doubtless have already noted is that many of the subjects of our program are treated in the form of reports or reviews rather than through the presentation of individual practices and experiences. Practices and experiences of the individual are, of course, always of fundamental interest but it was thought advisable, for once at least, to treat some of our subjects in their broadest aspects and we trust that you will approve of this departure from the more usual custom.

The sponsors of the conference appreciate fully the efforts that have been contributed toward making this gathering a success. They are indebted to the speakers on the program, to the various Federal, state and municipal officials for their participation; to the officers of the City of Memphis and the committees which will enable us to combine comfort and pleasure with our business and, above all, to the many of you who honor us by your presence here today. With these acknowledgments I now declare the Ninth Annual Asphalt Paving Conference open and I hope that you will find it a profitable one.

PRESIDENT LAW: Ladies and Gentlemen, the next speaker on the program scarcely needs any introduction. He is well known to all of you. His name is intimately associated with asphalt and asphalt constructions. It is a great pleasure to introduce to you Mr. Prevost Hubbard, who is President of the Association of Asphalt Paving Technologists.

# Progress in Asphalt Paving Technology

## By Prevost Hubbard, New York, N. Y.

*President, The Association of Asphalt Paving Technologists*

The Association of Asphalt Paving Technologists welcomes the opportunity again of holding its annual session during the Asphalt Paving Conference. Two years ago, our past president, Mr. Leroy M. Law, outlined to you the need for our organization and the work which it hoped to accomplish. Briefly stated, its purpose is to advance the technology of asphalt pavement construction. Technical advancement involves intelligent and painstaking research. The rate of progress, therefore, is limited by the facilities available for research and the rapidity with which these facilities can be put into operation. While considerable progress already has been made during the past few years, much remains to be accomplished. The funds available for research are unduly limited and many of our qualified investigators are seriously handicapped by this fact.

Since our association was organized, notable progress has been made in connection with the problem of design of asphalt paving mixtures. Methods of determining the structural strength of such mixtures have been devised and, by means of these tests, various factors affecting both structural strength and durability systematically have been evaluated with the result that certain old and faulty theories and rule-of-thumb methods have been revamped or totally discarded as more exact information has been obtained. Many elements of uncertainty with regard to the design of asphalt paving mixtures, therefore, have been eliminated.

The technologists are, however, not only concerned with the field of design but with methods of manufacturing paving mixtures and all details of their use in highway construction. Cooperation on the part of the manufacturer of plant and construction equipment, and with the contractor and the engineer on methods of construction, are essential to translate into service results, information secured from research on design. No matter how perfect a mixture formula may be, unsatisfactory results will be obtained unless the plant produces a uniform mixture in conformity therewith, and the mixture then is laid and thoroughly compressed to produce a smooth riding surface.

## Improvement in Paving Plant Operation.

At the present time there is much need for improvement in the details of the mechanical control of paving plant operation so as to increase uniformity of output and reduce variations which are now largely dependent upon the skill and judgment of plant labor. In this connection, such matters as mechanical methods of reducing or preventing aggregate segregation, automatic control of temperatures, as well as of weighing or proportioning each constituent of the mixture, and also automatic control of the time of mixing, are needed improvements.

In the field of construction, considerable advance has been made in the substitution of mechanical means of spreading asphalt paving mixtures for hand methods previously followed. Improvement and more general adoption of mechanical spreading is to be looked for as a distinct advance in the technology of the art. Improvement in methods of compressing hot mixtures particularly is needed. It is a rather peculiar fact that for more than fifty years, the common method of compacting asphalt pavements is one that tends to form, during construction, the very type of defect which it is hoped that traffic itself will not produce in the finished pavement. I refer to the road roller which requires a high degree of skill on the part of the operator, to produce a uniform and smooth riding contour, free from waviness. The technologist vitally is interested in the development of some method of initial compaction which will absolutely prevent the formation of contour irregularities during construction, as his researches on design have been directed particularly to obtaining mixtures which, under modern traffic, will not develop such contour irregularities. Some form of tamping device to precede the roller is indicated as a logical solution of this problem and it is to be hoped that important developments along this line will materialize in the near future.

I have mentioned only a few of the matters connected with the higher types of asphalt pavements with which the technologists are concerned. They equally are interested in the secondary types, commonly known as "low cost roads". The development of asphaltic products best suited for use in surface treatments, "mixed-in-place" construction and the preparation of premixtures to be laid cold, are of equal concern to them and, as in the case of high-type pavements, we find again that their interest reaches out to include machinery and equipment and details of construction. The best utilization of available local mineral aggregates is of particular importance in connection with such types, as the ultimate of economy is recognized as a necessary factor in their technical improvement. An almost limitless field of research presents itself in connection with the use of the liquid and semi-liquid asphaltic products for highway treatment and construction with local aggregates. Many of us feel that the greatest prospective growth of the asphalt industry lies in this field.

### Evaluation and Control of Subgrade Support.

At this time, I will not weary you with a list of other problems which are engaging the attention of the technologists, but there is one of such general importance that I cannot refrain from mentioning it. This is the evaluation and control of subgrade support. Subgrades are, of course, of vital interest in connection with all types of highways and a very great amount of study has been devoted by various highway agencies to the classification and characteristics of natural soils. Much of the published information resulting from these studies is so involved as to be of little immediate practical value to the highway engineer. It is believed, however, that the way has been paved for a rationalization of this subject which should take place shortly. Probably the most important characteristic of a soil, which has direct bearing upon the behavior of the overlying road surface, is its absorption of moisture by capillarity. This depends not only upon the composition of the soil material but upon its physical structure, and some practical method directly of measuring the load supporting value of soils, as influenced by capillarity due to composition and physical structure, is much needed. Prevention or control of capillary absorption for a substantial depth below the wearing course of a highway, would result in tremendous economies in the construction of the wearing course proper and it is believed that asphalt will play an important part in solving this problem by its use either for the purpose of

St. Mary's Avenue at Twenty-Sixth Street, Omaha, Neb. Asphalt Pavements are as Popular in the Middle West as in Other Sections of the Country. Omaha has Served Streets More than Forty Years Old Still Gives Splendid Service.

changing the soil texture, or as a waterproofing membrane inserted within the subgrade itself.

To the public executive charged with the administration of highway funds, technical research frequently is something vague and rather mysterious. The contractor is inclined to view it with tolerance until it interferes with his old established methods of operation, when his attitude changes to hostility. The material salesman is apt to consider it as a necessary adjunct to progress which is often a nuisance but may sometimes be turned to his advantage. The average engineer recognizes its value when reduced to practice, but frequently is justified in considering it as too highly theoretical in character. The technologists appreciate these different viewpoints and, as rapidly as possible, are endeavoring to reduce to practical application, facts developed by research to eliminate useless requirements from specifications and to present their findings in as easily understandable a form as possible.

Not less than a quarter of a billion dollars is being spent annually by the United States in the construction of asphalt wearing courses for highways. It is estimated that less than one-tenth of one per cent of this amount is being spent for research. At least five times as much should be made available. Modern progress is largely dependent upon research which, when properly applied, will produce not only better but more economical asphalt highways, solve many of the troublesome problems confronting the contractor, increase the market for materials and eliminate the uncertainties which the engineer now must face for lack of technical data. Close cooperation of all concerned is essential to rapid progress and such conferences as the present offer the best possible means of affecting this cooperation.

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PRESIDENT LAW: Gentlemen, it has been stated that our highway program is associated with other problems. It is associated not only with the present problems involved in the economic situation of the country, which we all agree are merely temporary, but it is associated with problems of a vastly more permanent character. For instance, we have other methods of transportation besides those afforded by the highways, particularly the enormous railway systems which have already been built throughout our country. The coordination, therefore, of rail and highway transportation is a very fine subject to be discussed in a meeting of this kind. We are very fortunate in having with us a gentleman who is well equipped to handle this matter for us, and I take great pleasure in introducing Dr. C. S. Duncan, economist of the Association of Railway Executives, Washington, D. C.

# Coordination of Railway and Highway Transportation

## By Dr. C. S. Duncan, Washington, D. C.

*Economist, The Association of Railway Executives*

I noticed that the first speakers were careful to say "Ladies and Gentlemen" and it gave me one of my first surprises, because I was unaware up to that time that ladies built any of our highways. But I noticed that after taking one glance at the succeeding speakers all of them left. I suppose they came to see the handsome representatives of the state, county and municipal governments in Tennessee.

The other thing that surprised me was a remark made by your president as to the handicaps that you feel from governmental restraint. Coming from the railroad field you can imagine what a surprise it is to me that you should feel the heavy hand of government in your business. I had thought you were as free as the birds of the air compared with us, because, as somebody facetiously remarked not long ago, the only thing a railway executive can do without first consulting the Interstate Commerce Commission is to sneeze when he has a cold. If you want to know what the government can do with its heavy hand of regulation, acquaint yourself with the railroad industry.

The invitation that you have so courteously tendered me to appear on your program included as a suggested subject for discussion the relationship of railroads to improved highways. It is an honor and a privilege which I greatly appreciate, to appear before you today in an attempt to present to you the problems involved in this intensely interesting and highly important subject.

### Relation of Railroad and Highway Service.

It is obvious to us all that the construction of our railroads and the construction of our highways have the same end in view, namely, transportation—the carrying of goods and persons from one place to another. Both are intended to be servants of the public in the successful transaction of business—the essential service to the public of carrying goods from points of production to points of consumption,—as well as to enable the people of our country to travel back and forth speedily, safely and comfortably. Diverse as they are in the materials out of which they are made, rails and roads are united in their purpose and in their service,—that is, economical, dependable, adequate, safe and comfortable transportation.

It likewise is obvious that the railroad in itself and the highway in itself make up only one part of a transportation system. The other part consists of the facilities for transportation, the means of locomotion and the vehicles for carrying goods and persons. The facilities, their materials and their construction, necessarily are adapted to the roadway over which they run. In this respect there is a rather broad difference between railroads and highways as transportation systems. It is clear that there is an influence running from the character of the road to the type of facilities operated over it and likewise there is an adjustment of the facilities to meet the requirements of the road. Different as they are in materials and construction, both as to roadway and equipment, rails and roads meet on the common ground of public service. Out of this fact grow the problems of their relationship.

### PROGRESS OF AMERICAN TRANSPORTATION.

May I call your attention to a statement appearing in an important report by the Interstate Commerce Commission, as a result of a nation-wide survey in 1926 of motor-bus and truck operation? Usually a report by the commission is a somewhat prosaic and matter-of-fact statement but in this particular one the opening passages are an appeal to the imagination and have even a touch of transportation romance. The passage to which I refer reads as follows:

> Indian travois and canoe, ox cart, pack horse, Conestoga wagon, stage coach, canal barge, steamboat, steam railroad, electric railway, motor vehicle, airplane—these words spell the progress of transportation in America.
>
> The economic structure of the United States progresses almost directly in relation to the development and efficient functioning of its transportation facilities. Settlements in the beginning were chiefly on or near the coast or on navigable waterways. The steam railroad prepared the way for the peopling of vast domains and afforded ready communication between the different parts of the country. The first railroad enterprises met with opposition from existing forms of transportation and the value and utility of the railroad as an agency of commerce and communication was not immediately recognized.
>
> The era of railroad expansion marked the beginnings of great industrialization. Industrial centers were linked together and distribution throughout the vast areas of the country was made possible. Without such a transportation system the present industrial development could not have been attained. Then came the electric railway. There was needed, however, some agency which would permit the fullest development of the country's economic situation by permitting transportation and communication to reach remote communities through territory not able to support costly railroad facilities. This need has been supplied by motor-vehicle transportation, flexible and composed of small units, so that many remote communities are now served by such agencies and enjoy the benefits of practically direct rail service.

You will observe, in the first place, that the commission, in describing the progress of transportation in America, referred to the facilities available for carrying goods and persons without reference to the road or highway upon which they were to operate. From this enumeration of facilities, however, it is apparent that as to the roadway the steps of progress in transportation were rivers, dirt roads, canals, railroads, improved highways and the "trackless pathways of the air". Already, in the commission's analysis, not only the railroads but likewise the splendid hard surface highways of the country have fallen behind the foremost place in transportation development.

### IMPORTANCE OF THE RAILWAY SYSTEMS.

There is another important observation that the commission has made as a result of its study. To the railroads it has accredited the present industrial development of the United States. Electric railways, the commission dismisses with a mere word. With respect to the transportation system by motor vehicles over improved highways, it says that this type of transportation may best serve to reach remote communities through territory not able to support costly railroad facilities, so that with its flexible and small units such remote communities may be served by such agencies and enjoy the benefits of practically direct rail service.

FAMOUS RIVERSIDE DRIVE, NEW YORK CITY. THE ASPHALT BOULEVARDS OF AMERICA'S GREAT METROPOLIS ARE NOTED FOR THEIR BEAUTY, DURABILITY AND SMOOTH RIDING QUALITIES.

It seems to me that the Interstate Commerce Commission, in surveying the transportation facilities of different types in the country, had come to the conclusion that the fundamental system was the railroads and that the improved highways for motor vehicle transportation should be supplementary thereto.

If this opinion of the Interstate Commerce Commission were and had been the policy of our Federal, state and local governments with respect to the improvement and use of our highway system, the problem of the relationship between rails and roads would be simple of solution. Apparently such has not been the policy of these units of government and, therefore, the problem of relationship is more complicated.

In this field of railroads we have the trunk-line systems, the branch or feeder-line systems and the independent short lines. These different types of railroad have been coordinated in their operation for the common purpose of serving the needs of the public most effectively. The Class I railroads, i. e. those with one million dollars or more of annual revenues, aggregate a little more than 238,000 miles of road, representing about 92 percent of the total miles of road in the country and, due to their longer haul, receiving approximately 96 percent of the total rail revenues. Through long years of endeavor to meet a common purpose, the trunk lines, the branch lines and the short lines have been coordinated into an effective national transportation system by rail.

## Growth of the Highway Systems.

The total highway mileage in the United States is 3,016,281 miles, of which 315,000, or about 11.5 percent comprise the state highway systems and 2,701,281 miles, or about 88.5 percent, are county and local roads. By 1929 the total highway mileage surfaced was 660,000 miles, of which the state highways aggregated 210,000, or 46.6 percent, and the local roads 450,000, or 53.4 percent. However, of the 315,000 miles of state highway, 66 2/3 percent were surfaced by 1929, while of the 2,071,281 miles of local roads only 16.6 percent were surfaced. That is to say, the state highway systems, representing only 11.5 percent of the total road mileage, have 66 2/3 percent of their mileage improved, while county and local roads, representing 88.5 percent of total, have only 16.6 percent of their mileage improved.

It has been calculated that in 1927, out of a total expenditure for highway improvement of over $1,465,000,000, the state highway departments supervised the expenditure of 45.3 percent and the counties 54.7 percent. Obviously, the tendency has been to concentrate on the development of the state highways program which corresponds most nearly to the trunk-line railroad systems. I may add that from 1914 to 1929, inclusive, about $10,670,000,000 have been expended on highway improvement. In 1929 the total mileage surfaced was 50,000 miles, at a total expenditure of $1,500,000,000.

A part of this state highways system, however, is included in a Federal aid highway system, the total approved miles of which equal 188,857. Of this amount 78,096 miles have already been completed with Federal aid. The total fund paid by the Federal government to states for this improvement to the end of 1929, was $719,582,994. An additional $75,000,000 were authorized for 1930 and $125,000,000 for 1931.

An inspection of the map of this contemplated Federal highway system indicates clearly that it seeks to join large population centers, most of which have been built up by the railroads and, therefore, for the most part, it parallels and offers competing service with railroads in transportation. While there is likewise a certain amount of competition with respect to the highways serving localities and communities, these naturally are to a greater extent supplementary and complementary. They fall more nearly into the program outlined by the Interstate Commerce Commission. On the whole, it may be said that rails and roads are competitive when they seek to perform the same service and strive to secure the same traffic.

### COMPETITION BETWEEN RAILROADS AND HIGHWAYS.

It is a fact that there is competition between rails and roads today, both in passenger service and in freight service. Passenger revenues on the railroads have declined about 40 percent since 1920. In 1929 there were over 23,000,000 automobiles and buses registered in the United States, which, presumably, were running over our improved highways. Among this number there were 92,500 motor buses which are estimated to have carried 422,000,000 revenue passengers between cities in common carrier service. In the same year the railroads carried about 780,500,000 revenue passengers. The figures for revenue passenger miles, for 1929, show about 6,800,000,000 for buses in intercity traffic as compared with something over thirty-one billion for Class I rail carriers. It should be added that 2,389 motor buses were operated by railroads.

Passenger travel is a mixture of personal convenience, comfort and cost. In the matter of personal convenience and comfort, the economics of competition plays a small part. Relative cost is a direct and substantial element in economics competition. In freight service, the motor truck has lengthened its radius of operation steadily during the past ten years or more. It first displaced the horse drawn truck that had been coordinated with rail carriers in local and city traffic. The motor truck now has gone far beyond this service. Economical operations up to 500 miles are claimed for it.

There are truck operations from points of production to market centers, carrying farm produce, in which railroads formerly participated. Milk, truck crops, fruit and cotton are handled extensively in this way. For example, the government figures show that livestock was hauled from the farm to sixteen principal markets by trucks in 1928 in such volume as to represent 152,000 carloads.

Trucks are operating in industrial and merchandising fields also. There are truck operations between New York and Boston, Albany, Philadelphia, Pittsburgh, Baltimore and Washington and between Chicago, Detroit, Cleveland, St. Louis and the "Twin Cities;" between St. Louis and Kansas City, from Kansas City to Denver, from Los Angeles to Phoenix,—upward of 470 miles,—and to Tucson, Arizona,—502 miles.

It is apparent that these operations are not confined to local service either at the point of origin or destination. It is also true that these truck operations are not confined to less than carload short haul traffic. Short haul is a relative term to be sure, but movements up to 500 miles by any definition cannot be called short hauls.

Likewise the kind of traffic involved shows that it is adapted to carload handlings, such as lumber, steel, fruits and vegetables, cotton, hay, canned goods, iron pipe, automobiles, livestock, newsprint paper, milk, furniture. In fact, there are many instances where a modern truck with its trailer handles a full carload. Here is real competition. It is competition that should be considered on an economic basis; that is, on a basis of relative total cost. It should be added here also that the rail carriers employ some 6,000 motor trucks, exclusive of 9,759 motor trucks operated by the jointly owned railway express agency.

## RAILROADS BUILT BY PRIVATE ENTERPRISE.

This competition between rails and roads is different from the competition that exists between rails and rails. The rails are a private enterprise, even though devoted to public service; are operated at private expense and are founded on a basis of private capital. In the beginning, railroad construction was attempted by state governments but failed so utterly that the railroads were abandoned to private enterprise. It is, therefore, private enterprise that has constructed the great system of railroads in the country, that has been responsible for their development and progress. Private enterprise has had to carry the burden of the pioneer work, reap such rewards as it could and suffer such losses as occurred. The highway, on the other hand, is a government enterprise, located under government policy, constructed at government expense and, except for such tolls as have been collected, these expenses have come from taxation.

BROAD STREET, WEST OF YOUNG, COLUMBUS, O. PAVED IN 1907 WITH SHEET ASPHALT ON AN OLD NATURAL CEMENT BASE. THIS PAVEMENT, THIRTY-FOUR FEET WIDE, IS NOW CARRYING 16,000 VEHICLES DAILY.

Here is a competition of private enterprise, on the one hand, and government enterprise on the other. Now it will be admitted without question that private enterprise must justify itself economically or disappear. A government enterprise may be sustained politically, though at a loss to the general public. Not only are the rails private highways but there is a joint private ownership of road and equipment facilities. A railroad represents a unified control of operation with private responsibility. Improved roads are public highways over which private facilities operate. The result is a diverse control of facilities and highways and more or less indefinite responsibility. The problem raised by this situation is baffling. That problem is: How can fair competition be maintained so that on the basis of even handed justice the best transportation system may be preserved for the public service? The rails can rightly, and do, ask no more than a correct answer to this inquiry.

## THE PROBLEM OF WATERWAY DEVELOPMENT.

A somewhat similar problem is raised by waterway development. There one finds large government expenditures for the improvement and maintenance of the navigable highway system. There one finds even government operation over this government highway in competition with private enterprise. There one also finds no tax or charge upon the users of the waterway to recompense the government for the expenditures it has made in construction and maintenance. And there is a further difference in that the carriers by rail get traffic directly and indirectly from highway development while waterways simply prey upon railroad traffic.

A difficult complication arises also from the fact the whole program of modern highway development was adopted primarily in response to the wishes of, and primarily to serve, owners of private passenger automobiles. But the highways, having been improved, offer an incidental or accessorial service to motor buses and motor trucks, for private gain or profit—an operation, in fact, that should be considered strictly on an economic basis.

An analogous situation again is found in waterway development. Take the Panama Canal, for example. The record will demonstrate how large a factor in its promotion was the national defense. But, once completed and in operation, it is available for commerce. In true equity, what should be the basis of this commercial use of the canal? And again, there are very large expenditures for flood control on our rivers. These expenditures help to make available a navigable highway for commerce. What, in justice, should be the economic basis of these commercial functions?

To this extent, at least the answer is clear. Whatever additional expenditures are made, both for construction of the highways to fit them for commercial use and for maintenance as a result of such use, should justly be charged against commercial users. It must be admitted that there is no yardstick available today by which to measure such additional charges, but, nevertheless, the principle is sound. Need may arise to construct an improved highway solely for commercial uses in order to obtain information on this subject.

## GOVERNMENT SAVINGS FROM LAND GRANTS.

The point sometimes is made that the rail highway was subsidized in its great period of development by enormous grants of land. It is true that such land grants were made, but there is another phase of the matter not frequently noted, namely, what the government has received and is receiving for these grants. In the first place, land grants apply to about 15,316 miles of road out of a total of more than 265,000 miles. Secondly, for more than fifty years the government has been getting a mail rate on the land grant mileage on a basis of 80 percent of the commercial rate, and a rate only fifty percent of the commercial rate on materials and troops, and representing a reduction of about 12 percent annually on all rail shipments.

What does this mean in cold facts? As the commission has pointed out the present agricultural and industrial development of our country is due to rail transportation. The increased value that such transportation service has contributed is beyond calculation. But aside from all that, the annual direct monetary savings which the government receives from these ancient land grants in reduced rates is now, in peace time, more than four and one-half millions of dollars. Now, these grants were made between 1850 and 1870, and the government records show that the average amount received by the government for land disposed of in this period, and a market for which was created by the railroad itself, was 94 cents per acre. If this figure is applied to the acreage in land grants, it will be found that the railroads, even on a peace time basis, pay for these land grants every thirty-three years. The mail rates became effective in 1876 and some of the freight rate reductions have operated for 75 years. Thus, the term "grants" as applied to these lands has a bitter tincture of irony in it. The government no longer gives, but continues to take. Under existing law, these benefits to the government will continue to accrue for all the future. It is a factor for consideration in rail and road competition.

## RAILROADS NOT OPPOSED TO ROAD DEVELOPMENT.

Here is the competitive situation out of which the problems of relationship between rails and roads grow. To be sure, the development of a highway system over which speed has been so greatly increased has intensified existing difficulties, such as, the increasing hazards at highway crossings. These difficulties, however, are being met, although in such a way that the railroads certainly are carrying their full share of the responsibility.

American business believes in competition, which often has been called the life of trade, and is supported by the argument that, although necessarily it means a duplication of facilities and service, the ultimate results are better service at lower cost. Competitors themselves, therefore, can go no farther than to insist that the rules of the game of competition shall be fair to all interested parties.

The railroads have recorded their position as one which offers no obstacle or protest to the proper and successful development of any form of transportation that the public desires. Like every other competitor, they ask simply that the public be informed fully as to whether or not such development economically is justified in so far as it holds itself out as a business enterprise where all costs are to be met from revenues obtained from the service. This is true particularly in any case where government funds derived from taxation, to which the railroads are most generous contributors, are involved.

I cite, simply as an illustration of the point, a recently quoted statement from a member of the Indiana Public Service Commission. In a case concerned with the abandonment of certain unprofitable rail lines in his state, he said that if such lines continued to be abandoned some counties would find themselves bankrupt. If such a situation exists, it can only mean that the railroads serving such communities have been sustaining county solvency out of funds invested in railroad property. While I am not directly informed about the matter, I would be surprised greatly to learn that these very counties did not have improved highways which had contributed to the county indebtedness. Is that a fair competitive situation?

### FAIRNESS IN THE RULES OF COMPETITION.

The rules of the game of competition ought to be fair to all parties interested, in connection with transportation as elsewhere. The general principles underlying fair competition between rails and roads may be clearly stated. Their application is more difficult.

(1) The aim in the public interest is to secure the most economical, continuous, expeditious, responsible, dependable, safe and efficient transportation service at the lowest possible cost.
(2) In determining the system of transportation which is most economical, *all* of the costs must be considered.
(3) Railroads ought not to be handicapped with greatly restrictive regulations as to costs, operations or earnings while their competitors go free.
(4) Railroads ought not to be burdened by any share of the expenses of experimentation in other competitive modes of transportation.
(5) Railroads ought not to have inroads made into traffic developed by them, by irresponsible, or undependable, or non-continuous, or selective competition.
(6) New and experimental systems ought to make their own way on an even handed basis without subsidy or favor or unassumed costs.
(7) All problems connected with rails as well as roads, as they arise, should be considered and settled as economic questions, which they are, and not as political issues, which they are not.

Our country must have the best transportation service that invention and enterprise can develop. We ought to experiment with different forms and types. If this means competition, let competition come. If this means substitution, then let it come also. Competition means change. Change means progress. Progress means better service.

And in this progress toward better service our common aim should be to find out the limits of the field, if such limits there be, to the economical operation of each type of transportation. As we learn these things, let our common purpose be to bring all forms and types together in such a relationship as will result in a coordinated service, into a national transportation system with all parts articulated and harmoniously, progressively and cooperatively serving the public.

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PRESIDENT LAW: Another one of our problems which already has been referred to is that of the farmer and all-the-year-round transportation. If we could look into the future and visualize the ultimate development of this program, we would see that every farmer's gate can become his shipping point. Mr. Norman M. Blaney has selected this subject for an address and I am sure he is well qualified to deal with it. Mr. Blaney is director of farm-to-market roads for the American Farm Bureau Federation, and I take great pleasure in introducing him.

# Making Every Farmer's Gate His Shipping Point

## By Norman M. Blaney, Chicago, Ill.

*Director of Farm-to-Market Roads, American Farm Bureau Federation*

If I understand the invitation which has brought me here today, this conference desires to know what has been accomplished by the American Farm Bureau Federation to promote the construction of farm-to-market highways. It is an invitation which I have accepted with great pleasure because there is so much of our work in which I am sure you will be interested. Chiefly I shall talk about ourselves,—about the farm bureau and what it has done. But if you will pardon me, I shall also make use of the opportunity to point out a line of conduct, which, in my judgment, if you follow it, will prove profitable to yourselves.

From the standpoint of American agriculture there is no question as to the economic and social necessity of an adequate farm-to-market road system. Unless the farmer has a highway from his front gate to his primary market, passable for 365 days in the year, he is seriously handicapped.

Such is the case with approximately 80 percent of the farmers in America. Nearly 5,000,000 farms are located on dirt roads which are impassable during many months of the year. It is not for the farmers living on these impassable dirt roads to say when they will sell the product of their toil. The controlling factor is the condition of the dirt road over which their crops must be hauled. The seriousness of this situation from the economic, the social, the educational and the medical, as well as the fire hazard and from the young people's standpoint, cannot be over emphasized. As to the desirability, in fact the absolute necessity, of adequate farm-to-market roads, there is no question. The future progress and prosperity of American agriculture absolutely demands farm-to-market roads.

### Importance of Good Roads to Farmers.

Unfortunately, obtaining such highways involves numerous economic, engineering and political problems. And to help the farmers of America solve those problems and secure for themselves year-round roads, the American Farm Bureau Federation, during the past year, has contributed the resources of its entire organization,—national, state, county and community.

From the early beginning of the American Farm Bureau Federation, the importance of our rural highways as factors in the welfare of farmers has been insisted on. When the question of Federal aid for highway construction became an issue in Congress, the American farm bureau arose as the champion of interstate roads for business purposes rather than for pleasure driving. The educational campaign that was embarked upon at that time, engineered the nation into a proper conception of the kind of roads most needed by the farming class. Not broad boulevards for fast driving, but roads that would serve as arteries of commerce,—those were what we proposed at that time.

It was not, however, until the beginning of 1930 that our farm-to-market road program became a major project of the organization. Our board of directors, after due deliberation, instructed our executive officers to establish a new service at national headquarters in Chicago, for the conduct of the campaign, the aim of which is to promote the construction of adequate farm-to-market highways. Your speaker was appointed as the first director of this new farm bureau service and believe me, it is a project of most absorbing interest.

Just the other day, as I was preparing to come down here, there came to my desk a brief line or two which epitomizes what has been accomplished in the interval since the launching of our program. One of our organization field workers had been making a speaking trip through the State of Connecticut and at its conclusion he wrote out a report to national headquarters. The quotation from that report, which was sent to me from our secretary's office, says: "Farm-to-market roads are gradually being incorporated into the thinking of the Connecticut farmer."

### More Knowledge Needed as to Low Cost Roads.

And that, my friends, is something which is becoming quite generally true all over the United States. Farm-to-market roads *are* gradually being incorporated into the thinking of our farmers. I believe I am not overstating it when I say that the thought is practically unanimous.

Low Cost Sand Asphalt Township Farm-to-Market Road Near Brewster, Mass.

Farmers *want* good roads. They want roads on which they can depend the year round for their transportation needs. I do not wish to suggest that we should cease our efforts to make them further conscious of that need. That work must continue. I do say, however, that this educational campaign should be expanded to include a spread of the knowledge that year-round roads are possible *at low costs*. This fact has not yet sunk into that farmer mind typified by the report from Connecticut. Farmers do not yet realize that *their* community *can* afford year-round roads from their front gate to their market place.

I am reminded of an incident occurring at a road meeting in which I participated out in a western state not long ago. The farm bureau organization was talking road improvement for all it was worth, and the editor of the local newspaper was fighting the proposition with all the vim and vigor that country editors can throw into a cause that they feel is a righteous one. In our meeting this editor told of driving, just a week previous, over a stretch of road some hundred miles distant which struck him as the type of road the community should strive for. "But we don't have the money," he said, " to build that kind of a road."

It happens, however, that the stretch of highway to which he referred was not an expensive type of road. It had been built for $4,000 a mile, not the $30,000 or more which the editor thought it cost. And I imagine you can understand his feelings when that fact was brought home to him. His understanding of the matter is typical of much rural thinking on the cost of roads. Most farmers, and too many road commissioners in rural regions, seem to think there are only two types of highways,—one of them, gravel roads, etc., and other, the most expensive type.

## USE OF GASOLINE TAX FOR FARM ROADS.

On my trips around the country I find very little exact information among county and township elected officials on this matter. They know little or nothing about the different types of surface treatments for gravel roads that will make them satisfactorily serviceable without involving a tremendous cost. The consequence is that these men immediately start talking about expensive types of pavement, although failing to consider that they do not have sufficient money to expend on such types of construction. Nor do they have the traffic that would justify this expenditure and they are at a loss to know what to do about it. Every local official and the great majority of the country people know what cement concrete is as a road material. Yet an extremely small percentage have any acquaintance whatever with the various types of bituminous treatments. Nor do they see where bituminous materials fit into the program of road construction.

I would add here that our organization has no quarrel with the advocates of the more expensive types of roads. If there is money enough and the traffic justifies it, we are for them 100 per cent. Those roads must be built where they are needed but we need these others too, because so much more ground can be gained. There is great need, however, of a more vigorous campaign to spread knowledge of the less expensive types of surfaced farm-to-market roads.

It may be that more attention should be given to the importance of gasoline tax funds being used for farm-to-market road construction purposes. In some places there is a tendency to absorb part of this revenue in expenditures for administrative and other expenses. It is not a difficult tax to collect and every effort should be made to see that the funds are properly expended on farm-to-market road construction.

## EDUCATIONAL CAMPAIGN OF FARM BUREAU FEDERATION.

And now to the story of the American Farm Bureau Federation's educational campaign to interest the nation in year-round farm-to-market highways. The American Farm Bureau Federation has had a rather modest war chest at its disposal and yet we feel that with the means at hand we have rather well blanketed the nation and secured genuine results. Our accomplishments are due entirely to the nature of our organization. Perhaps you will want to understand what that is like.

The foundations of the farm bureau can be traced away out to Bird Center and Pumpkin Hollow, those extremely rural communities much favored by the cartoonists. I would ask you, however, not to treat Bird Center or Pumpkin Hollow lightly. Not only does the farm bureau find its origin there, but those communities are the bed rock on which our nation rests. When men are needed for a national undertaking, the men —and the women, as well,—in those rural regions are always ready quickly to assume their full share of the burden.

In those remote communities the farm bureau has organized its township farm bureaus. There may be fifty, there may be a hundred farmers with their families grouped into these elementary units of the organization. In turn, these township farm bureaus unite into a larger unit which embraces the county, while the county in its turn joins forces with other counties in forming a state farm bureau federation. And, finally, the state federations unite to form the American Farm Bureau Federation, the national organization which I represent.

There are now some 15,000 township groups organized. The county farm bureaus number 1,837 and the state federations allied with the national organization number 43. In this membership we count more than a million and a quarter farm families. It is the largest organization of farmers in the history of the world, and its potential influence for shaping the course of events is tremendous. It has been our task and our pleasure this past year to arouse in this vast army of farm folks the desire to *do* something about the farm-to-market highways, and we have kept at it pretty much of the twenty-four hours each day.

## MORE FUNDS SECURED FOR ROAD BUILDING.

In our intensive national educational campaign the story of farm-to-market roads has been carried to the remotest hamlet. The printed page, the public speaker, the radio, the motion picture and numerous other educational and publicity mediums have been utilized in spreading the message of the economic and social advantages of adequate farm-to-market roads. It has echoed from coast to coast and from the humblest village hall to the office of our nation's chief executive.

With reference to this last statement I do not believe there is any secret about it, but you will recall that one year ago President Hoover summoned representatives of the principal industries to Washington for a conference to consider ways and means of relieving the business depression and unemployment. President Sam Thompson of the American Farm Bureau Federation went down to the capital to speak for the farmers and he took advantage of the occasion to urge upon the President the desirability of pushing road construction, both as a national and a state measure for the relief of the situation. The suggestion was adopted and it has become a national and state policy to the decided benefit of everybody concerned.

Congress accepted its responsibility in excellent time and, as you well know, made an emergency appropriation of $50,000,000 for Federal aid to state highway construction work, available for the fiscal year of 1931, in addition to the $75,000,000 previously appropriated. At the same time the national law makers decreed that for the two fiscal years, 1932 and 1933 the Federal aid funds should be $125,000,000 annually. Our good friends, the United States Bureau of Public Roads, in a statement released one month ago on November 9th, revealed the interesting information that when the $50,000,000 additional funds were made available, the states immediately responded by increasing the allotments for definite projects to $102,498,084, as compared with $70,428,896 during the last fiscal year.

### FAVORABLE REACTION FROM PUBLIC OFFICIALS.

I do not want to burden you with too much detail concerning our campaign; rather I will attempt to give you some of the high lights. First of all, we have told our story in the addresses of our national farm bureau executives. On every possible occasion the farm-to-market message has been featured in these addresses, delivered at strategic points where the influence of the speech would radiate widely and cause discussion. You may not realize how closely the farm bureau is woven into the public life of the nation, but in our audiences have been governors, senators, congressmen and other officials who keep their ears to the ground and "make hay" for their own purposes whenever the time is opportune. I do not say that deprecatingly because the wise statesman is he who acts as his constituents dictate. And it is indeed a significant fact that the high ranking officials of our government are interested in finding out what the farm bureau folks are thinking. Add to these higher-ups, the state, county and township officers who attend and participate in our meetings and you will realize that these addresses have been of immense value in promoting interest in our program.

In my own efforts to uphold my end of the project I have travelled from one end of the nation to the other, swinging out to the Pacific Coast, back to the Gulf States, or up to the "Land of Ten Thousand Lakes" and into the East. I have kept no record of mileage but I would venture a guess that I have come close to circling the globe twice during the past eleven months. The contacts I have made cannot be numbered, but they have been selected with the utmost care to make sure that the greatest good might be accomplished. In carrying on our program, we have, of course, made liberal use of the radio to broadcast the farm-to-market road message. On one chain of 93 stations we have projected this story once each week into the heart of the agricultural sections of the nation, stressing always the advantages of year-round serviceable roads and the great need for them.

### USE OF RADIO AND MOTION PICTURES.

Once each month, also, the American Farm Bureau Federation uses the nationwide network of the National Broadcasting Company for an hour's program. One of these monthly affairs was devoted entirely to the subject of farm-to-market roads. Featuring the program, a dramatization of the official A.F.B.F. motion picture entitled, "The Barrier" was presented. At the conclusion of the broadcast, listeners were offered a booklet on the subject of farm-to-market roads. Requests for this ran into the hundreds, while at the same time, due to popularity of the playlet, we were also asked for permission to use it on local stations.

BITUMINOUS TREATED SANDY GRAVEL ROAD ON STATE ROUTE NO. 18, BETWEEN ELK RIVER AND PRINCETON, MINN. A MODERN LOW COST FARM-TO-MARKET HIGHWAY.

This motion picture, "The Barrier," was produced under the direction of our motion picture division to extend the campaign for farm-to-market roads, and secure the organization of county farm bureau road committees. The film is highly entertaining. It opens with scenes in the jungles of Africa, where two American engineers have discovered a rich copper deposit. However, being in the heart of Africa, hundreds of miles from transportation facilities, the men are forced to abandon their wealth and return home. The scene shifts to a typical American farm community. One of the engineers has returned to his old home on the farm, where he finds that much the same situation prevails that had developed in "The Dark Continent." His father and neighboring farmers are isolated by mud roads and are unable to haul their produce to market where the pick is best. The farm bureau, however, takes a hand and through the organization of a county road committee, year-round low cost roads result, bringing prosperity to a blighted region. This film is proving to be most popular and effective in bringing home the importance of adequate farm-to-market roads.

Another motion picture, dealing with the farm-to-market road situation, with particular emphasis on the economic side as applied to cooperative marketing, is now being produced. This second film dramatizes the difficulties encountered by a typical community in its efforts towards cooperative marketing, one of the most serious of which is the lack of year-round roads. The fact that cooperative marketing depends *so largely* upon ability to deliver farm crops to the market at the right time, makes mud roads a most discouraging obstacle. It will be of special value in the organization of county road committees since it emphasizes dramatically the importance of a carefully planned county road program.

### CAMPAIGN WAGED BY FEDERATION MAGAZINE.

Our official organization magazine, *The Bureau Farmer,* has been another important voice for the farm-to-market road message. This magazine, edited and published solely for the benefit of American farm bureau members, has given most effective support to the road program with the articles and editorials that it has carried. In the "Bulletin Board," a special department appearing on Page 1 each month, our members have been kept in touch with matters of news value in the farm-to-market road situation.

A valuable feature of this magazine is that it is published in special state editions, affording an opportunity for the presentation of matters of special interest to any particular state. At community meetings in the remote hamlets to which I have referred, discussions of the contents of the magazine feature the programs. The leaders use it as a teacher uses a text book and this is what makes *The Bureau Farmer* so valuable for carrying information to the membership.

The Department of Information of the Farm Bureau Federation has played a leading part in all this publicity effort. Every outstanding event has been made the occasion of news releases to the press serving the territory most concerned. Without apology, I feel that I may say with pride that very few farm bureau news releases are thrown to the floor or into the waste basket in newspaper offices. The American Farm Bureau Federation has a high standing in the newspaper world and our relations with the press are mutually satisfactory.

### ADVOCACY OF MORE ROADS BY FARM PAPERS.

Another contact which has an immense bearing on results is the fact that as an agricultural organization the farm papers themselves are very much interested in our activities. To present our road program intelligently, personal calls have been made by our representatives on the editors of farm publications reaching a total circulation of approximately 12,000,000 farm families. Often the entire editorial staff has attended the conference in which the objectives of the American farm bureau road program have been explained and accurate information offered. In each case definite editorial plans for the farm-to-market road campaign have been worked out and our publicity department is busy supplying what is requested.

But you are growing weary of this detail and I shall linger on this subject only long enough to mention the hand books, the folders and special bulletins, and much other printed matter that has been prepared and distributed. The best talent available was employed in their preparation and they are proving of substantial value. To suggest how this material is exerting an influence, let me cite the case of the chairman of one of the state road committees we have helped organize. In his state he has taken hold of the project enthusiastically and is conducting a splendid campaign on behalf of farm-to-market roads. The interesting part of it is that in his publicity material he has been using word for word the material presented in our hand books, particularly that to be found in our road manual.

### Organization of Road Committees.

As the first definite and practical step towards farm-to-market roads, the American Farm Bureau Federation strongly has advocated the organization of state and county road committees for the analysis and study of particular road problems and the development of a workable farm-to-market road plan.

The results have been most encouraging. Up to November 25 state farm bureau road committees have been organized in the following twelve states:

Ohio
Illinois
Iowa
Wisconsin
Kentucky
Minnesota
Mississippi
Nevada
New Jersey
New Mexico
South Dakota
Texas

County road committees had been organized on that same date in 251 counties in twenty-nine states. This list is being augmented daily and before the year ends we are expecting to have road committees active in 300 counties,—the objective of this year's endeavor.

The organization of road committees has been the first step in our program. And when you realize that through these road committees, whose members are farmers, contact is had with actual road building activities, you will see that it is a very important step. An actively functioning road committee, giving time and thought to the local road situation, planning out a county-wide system, devising the most effective ways to secure it, and considering the best use of the funds available in cooperation with the highway engineers and road commissioners, and the financial and business interests of the community, holds an enormous power for securing direct results. Every one of these committees is a potential nucleus for a road building program of considerable importance. This list of county road committees is growing daily and the part they play is bound to increase in importance as the possibilities of their work dawn upon them. To increase the efficiency and effectiveness of these committees will be our constant aim. We shall endeavor to give them the utmost cooperation and we are expecting that as this feature of our service expands, time and attention will more and more be required to satisfy the natural demand they will make for help.

In passing, I want to emphasize that in any activity directed towards the farm people of the country it is necessary always to bear in mind that farm living, training and environment tend towards slow and deliberate action. The farmer likes to take time to think things over. He does not react either up or down with the speed of the average city man. Once resolved on a course, however, he goes steadily forward to a conclusion. We cannot, therefore, expect an immediate, instantaneous outburst of enthusiasm. Nor would such a result be desirable. Rather we would plant in the farmer's mind a deep realization of the importance and value of adequate farm-to-market roads and to inculcate a deep rooted determination to devise the ways and means of getting them.

Asphalt Surface Treated Limerock Roadway on State Route No. 3, North of Albany, Ga. A Type of Low Cost Surfacing Extensively Used in Georgia, Florida and Other Southern States.

You will realize, I am sure, that thus far our work has been largely that of preparation. This is the springtime period of our labors. We have been busy plowing and planting the seeds. Now must come the period of careful, constant, consistent cultivation and, as every farmer will tell you, if this summer season is safely bridged, we can hope for an abundant harvest in the fall.

### Farm Bureau Campaign a Foundation.

I want you to remember that the men who guide the plows down the long furrows of our agricultural empire, are actuated by an abiding principle which means much. Having once put their hands to the plow they do not like to turn back, and it will be well to ponder that.

Ours is a young organization as such things go. Next week in the City of Boston we shall hold our Twelfth Annual National Convention. The meeting is a feature of the Massachusetts celebration of the establishment of agriculture by free men in America. That event happened

300 years ago, so you can see we haven't much to talk about on the topic of our age.

I think you can, however, see that ours is an extremely virile organization. If any of you were to prepare a history of agricultural development during the past twelve years, I am confident you would find it difficult to write one single chapter without some reference to the American Farm Bureau Federation's part in developing public opinion for the support of the subject dealt with in that chapter. Cooperative marketing, inland waterway development, railroad transportation costs, taxation,—these and a score of other big problems which farmers face, have each occupied the attention of our organization, and, in the national attitude towards these matters, there can be traced the results of American Farm Bureau Federation thought and effort.

Our leaders still believe that one of the great needs of the farmer is that of year-round usable roads from his front gate to his market place. I shall not bother you with figures of the mileage to be covered. There isn't anything the American Farm Bureau Federation could do actually to cover them anyway. That is your job as highway builders. Ours is a foundation work. We must prepare the soil and sow the seed. Frankly, the surface has scarcely been scratched. But I am confident that with a continuation of the wonderful cooperation and assistance we have had in the past, the work can be continued during the year now just ahead of us and much good can be accomplished. Having put our hand to the plow we cannot turn back.

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PRESIDENT LAW: I am sure we have all been very much interested in hearing Mr. Blaney's discussion. From his intimate knowledge of the need for highways from the farmer's standpoint I do not believe there is anybody who could have given us a better picture of the situation. If there are any of you who have not read the booklets put out by the American Farm Bureau Federation I suggest that you get them immediately. You will find them very interesting. In considering progress in road building it is proper that we should look beyond our own confines and ascertain the experience of others, not only with reference to our state and national highway systems but those of other countries. North of us lies a great country which also has its road problems to solve, and its engineers are making great progress. There is scarcely a meeting we have had but what some of them have come down and contributed from their information and experience. Today we are again favored with the presence of a noted Canadian engineer. We have with us Mr. Homer P. Keith, chief maintenance engineer of Alberta Province in Canada. He will talk to you on the progress made with bituminized gravel roads in his province.

# Progress with Bituminized Gravel Roads in Alberta Province

## By Homer P. Keith, Edmonton, Alta.

*Chief Maintenance Engineer, Province of Alberta, Canada*

Compared with many of the states of the American Union and some of the provinces of Canada, we are very much in the pioneering stage of road construction in the Province of Alberta. For the most part we have, on our main highways, a system of gravel roads, and in a brief discussion today I shall endeavor to tell you what we are trying to do in the way of maintaining these roads. As your president has pointed out, the title of my address is "Progress With Bituminized Gravel Roads in Alberta Province."

The Province of Alberta inaugurated a program of gravel road surfacing in the year 1924, and now has a total of between 1,200 and 1,500 miles. As new roads were added each year and old ones re-gravelled, the available supply of material disappeared at an alarming rate. It was, therefore, very soon realized that some additional treatment was an urgent necessity in order that the gravel supply be conserved and a satisfactory and economical wearing surface provided. Accordingly, in 1928 a program of experimentation with bituminous materials in combination with local gravels was launched in an attempt to work out methods applicable to local conditions.

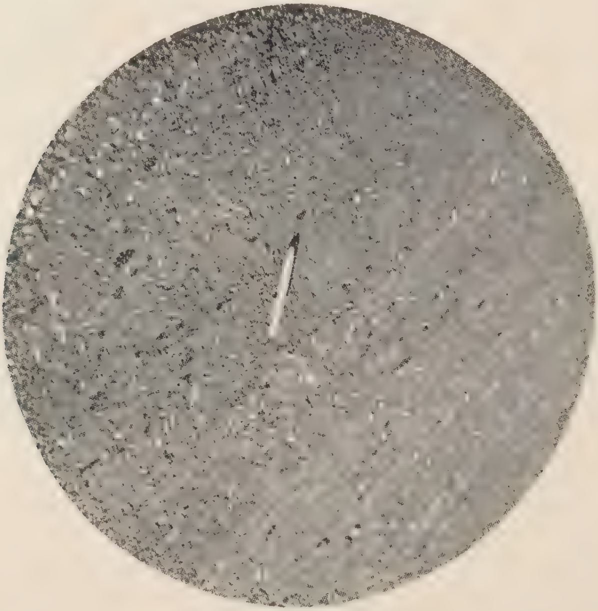
A consideration of the amount and character of traffic, financial resources, availability of suitable mineral aggregate and climatic conditions actuated the department in attempting the following bituminous treatments, viz:—asphaltic oil as a "dust layer", "surface treatment" or "flush coat", "mixed-in-place" and "plant-mix".

Asphalt oil as a dust layer has been used rather extensively in proportion to our total mileage during the past two years. The oil used at first was of low viscosity,—between 90 and 110 seconds Saybolt Universal at 130 degrees F. This later was modified to a somewhat heavier material—one with a viscosity of about 155 seconds Saybolt Universal at 130 degrees F. To facilitate working conditions, it is desired to apply the oil without heat, and next year it is the intention to raise the viscosity as high as possible and still permit cold application at ordinary atmospheric temperature.

### PREPARATION OF THE ROAD-BED.

Especial consideration should be given to the preparation of the road-bed prior to the application of the oil, so as to obtain a thin layer of loose "float," uniformly distributed over the whole width. For this purpose a heavy truck equipped with a spring blade was used immediately ahead of the distributor. The first application was at the rate of one-quarter of a gallon per square yard, after which ordinary gravel road maintenance was continued. The period of usefulness of the oil depends largely upon the condition of the road-bed and the nature and quantity of "float." A gravel containing a high percentage of clay, with a consolidated surface, will not give satisfactory results. Under ideal conditions, with a thin layer of hard, clean gravel, one application will last for practically the whole season, although in most cases, two are found necessary. The applications are made and the quantities varied from mile to mile at the discretion of the engineer directly in charge of the work.

FIG. I



SHOWING SURFACE TEXTURE OF COLD-MIXED ASPHALTIC CONCRETE IN WHICH WAS USED SCREENED GRAVEL WITH 81 PER CENT PASSING A QUARTER-INCH SCREEN.

A typical analysis of the dust layer used in 1930 is as follows:

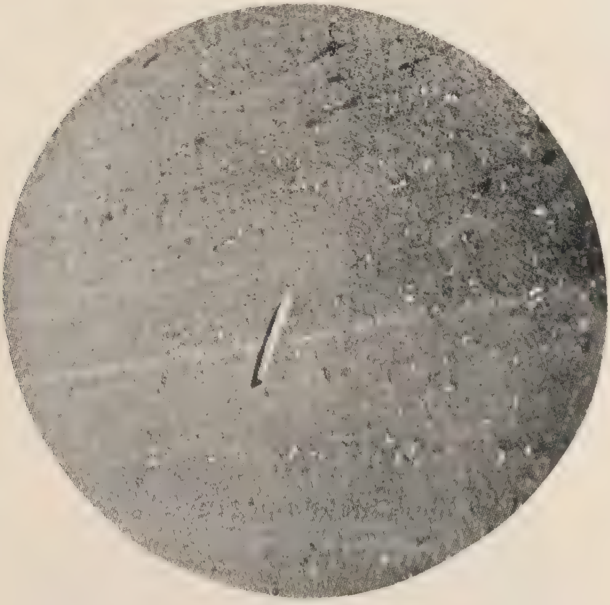
| | |
|---|---|
| A. P. I. gravity at 60 degrees F | 10.4 |
| Flash (open cup) | 285° F. |
| Viscosity Saybolt Universal at 130° F. | 155 seconds |
| Volatility at 325° F. 50 gms. 5 hrs. | 4.60 |
| Soluble in C. S. | 99.65% |
| Soluble in 86° naphtha | 76.54% |

As this type of work meets an insistent demand for the abatement of the dust nuisance, and also reduces the wastage of gravel, it is felt that the expenditure has been amply justified. It does not, however, produce a wearing surface capable of withstanding the traffic to which a large proportion of the highways is now being subjected, consequently sections have been laid during the past three years by using various other types of bituminous treatment.

### SURFACE TREATMENT AND MIXED-IN-PLACE METHOD.

Both "surface treatment" and "mixed-in-place" as used ordinarily, the methods of which are familiar to you all, were tried and, although some fair results were obtained, it was found that there were a great many disadvantages, principally due to our local condition. In Alberta, the road-bed width is only 20 to 22 feet, and for this reason difficulty was experienced in carrying on mixing operations without serious disturbance of the surface, especially where it was adjacent to the shoulders. A hole torn in the road surface by a turning tractor or grader is very likely to develop into a weak spot and result in failure. This can more easily be avoided in roads of greater width, as additional room then is available on the central and more compacted portions. Due also to this lack of width, it was necessary to detour traffic during the mixing operations, which at times proved very inconvenient, especially where side roads were not surfaced.

FIG. II



SHOWING SURFACE TEXTURE OF COLD-MIXED ASPHALTIC CONCRETE IN WHICH WAS USED CRUSHED AND SCREENED AGGREGATE WITH 68 PER CENT PASSING A QUARTER-INCH SCREEN.

The main reason against the adoption of either the "surface treatment" or "mixed-in-place" types in Alberta for any extensive program of bituminous work is due to our climatic conditions. It was known that in some sections of Canada, notably in British Columbia, very satisfactory results were being obtained by mixing in place with gravel, a non-volatile liquid asphalt having a viscosity as high as 650 seconds Saybolt Furol at 122 degrees F, and containing 80 percent to 85 percent of asphalt base of 100 penetration. This procedure was found to be impracticable in Alberta, due, no doubt, to the presence in the aggregate of a high percentage of very fine particles and to lower temperature conditions. Accordingly, a liquid asphalt of lower viscosity—one of 375 seconds to 450 seconds Saybolt Furol at 122 degrees F.—was tried.

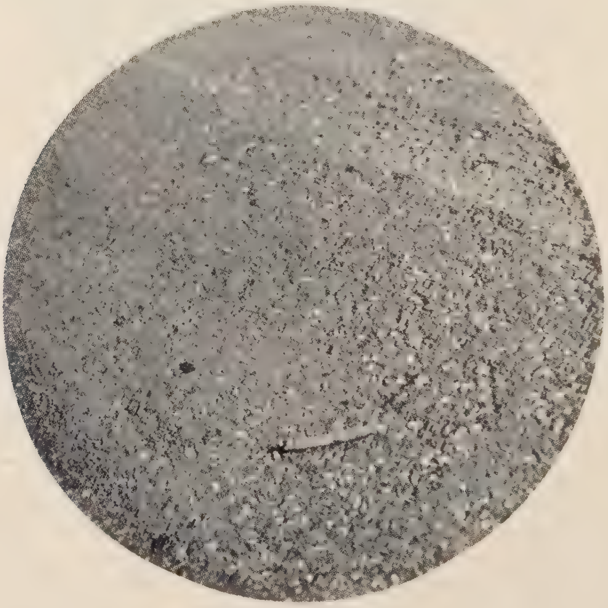
### WEATHER CHANGES CAUSE TROUBLE.

The first attempt with this grade was only partially successful. It was applied on a very warm day, and mixed in place by ordinary methods, using discs and blade graders. This method appeared to be proceeding satisfactorily, but unfortunately that night the temperature dropped and made it impossible to continue mixing operations for some time. When the weather turned warmer, it was found that mixing could be carried on successfully only for a few hours in the middle of the day. The viscosity of the oil having been lowered again to meet the general temperature conditions, it developed that sufficient binder had not been provided in order to retain a compacted surface. Frequent rains also resulted in costly delays.

After the experience of two seasons, it was apparent that some method less dependent upon our weather conditions must be found before proceeding with a program on a large scale. It then was decided to experiment with the "plant mix" method, as it appeared that we might in this way overcome some of the obstacles which had been encountered. Several miles of this type have been built during the past season, and, so far at least, the results appear to be very encouraging.

Arrangements were made for the delivery of varying grades of aggregate as well as asphalt from a number of sources. Combinations of these were made, and a total of between nine and ten miles of road was surfaced. The mixing was done in a hot-mix asphalt plant, which is permanently located near the site of the work. The aggregate was dried and mixed with the liquid asphalt in the manner common to hot-mix work. As the aggregate was charged to the mixer at between 150 degrees F and 175 degrees F., a liquid asphalt of comparatively high

Fig. III



Showing Surface Texture of Cold-Mixed Asphaltic Concrete in which was Used Crushed and Screened Aggregate with 54 Per Cent Passing a Quarter-Inch Screen.

viscosity could be used. The subgrade on which the experiments were conducted had been gravelled for a period of four years and treated earlier in the season with an asphaltic oil dust layer.

### PLANT-MIX CONSTRUCTION OPERATIONS.

Immediately prior to the placement of the bituminized material, the road surface was cleaned of all surplus aggregate. This is very important, since otherwise it will form streaks in the new surface which will necessitate removal and patching. The mixed material was hauled to the road, dumped, spread and consolidated by traffic. Rolling the surface was tried and discarded, for it was found that much smoother riding qualities were obtained by traffic consolidation, combined with occasional light blading for four or five days.

Experience indicates that non-volatile liquid asphalts ranging in viscosity from 700 to 1,200 seconds Saybolt Furol at 122 degrees F. may be used to produce mixtures which can be bladed for several days after placing, even in weather with a temperature as low as 40 degrees F.

Practically all mixtures were made approximately in the proportion of 30 pounds of liquid asphalt to 1,000 pounds of aggregate. With the facilities at hand, the proportion between asphalt and aggregate could be varied readily with definite knowledge, but the above was judged to produce the most suitable result. This, as you will note, gives 2.91 percent by weight of asphalt.

Analyses of both asphalt and aggregate which appeared to give the most satisfactory mixture, are given herewith:

### ANALYSIS OF ASPHALT.

| | |
|---|---|
| Specific gravity | 954 |
| Flash point (open cup) | 255° F. |
| Burning point | 295° F. |
| Viscosity Saybolt Furol at 212 degrees F. | 36 seconds |
| Viscosity Saybolt Furol at 122 degrees F. | 965 seconds |
| Volatility at 325° F. 50 gms. 5 hrs. | 6.86% |
| M. P. or pour on residue | Pour at 75° F. |
| Distillation % off at 680 degrees F. | 8 |
| Distillation residue % by weight | 93.4 |
| M. P. | 73° F. |
| Ductility at 77 degrees F. | Too Soft |
| % Soluble in C. S. | 99.7 |
| % Soluble in 86 degrees Naphtha | 76.1 |

### SCREEN ANALYSIS OF CRUSHED GRAVEL.

| | | |
|---|---|---|
| Passing | 1″ | 100% |
| " | ¾″ | 97% |
| " | ½″ | 92% |
| " | ¼″ | 68% |
| " | 10 Mesh. | 43% |
| " | 20 " | 33% |
| " | 30 " | 22% |
| " | 50 " | 09% |
| " | 80 " | 05% |
| " | 100 " | 04% |
| " | 200 " | 02% |
| Clay content | | 01% |

### ADVANTAGES OF PLANT-MIX METHOD.

The Province of Alberta appears to have been somewhat neglected as far as the distribution of road gravel is concerned. As a typical example, we might take our highway between Edmonton, the capital, and the City of Calgary, a distance of 200 miles, on which we have only two suitable gravel deposits. Train haul, with consequent freight charges, is unavoidable. When replacement becomes necessary, it would, therefore, appear to be a matter of wisdom and economy to install a plant mixer in the pit and ship bituminized instead of untreated gravel.

It is believed that on extensive work, and with the conditions encountered, the cost by "plant mix" will compare favorably with that of the "mixed-in-place" method. It is evident that the production of aggregate, delivery to road-bed and finishing will be approximately the same in both cases. We may, therefore, properly balance the cost of mixing in the plant against that of spraying and mixing on the road, with an appreciable credit in the way of reduction of asphalt in favor of "plant mix."

Some of the advantages of "plant mix" are as follows: (1) It is not seriously affected by changing weather conditions. (2) Increase in the length of a dependable working season. (3) It is unnecessary to detour traffic during construction. (4) As both aggregate and asphalt are weighed, uniformity of mixture easily can be obtained. (5) Excess moisture is removed from the aggregate. (6) A minimum quantity of high viscosity asphalt can be used.

Upon reviewing the work of the past three seasons and giving careful consideration to the experience encountered in that period, it is believed that the "plant mix" method is decidedly to be preferred for low cost road construction in the Province of Alberta.

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PRESIDENT LAW: Gentlemen, Mr. Keith's valuable paper on construction experience in Canada brings to a close the morning session so far as the printed program is concerned. It may be of interest to those who did not already know it that the United States Department of Commerce has a highway section, and I notice that Maj. B. P. Root, chief of this section, is in the hall this morning. I am going to ask Major Root to be so kind as to make a few remarks to us before we adjourn. I present Major Root.

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# International Cooperation in Highway Construction Methods

## By Major B. P. Root, Washington, D. C.

*Highway Specialist, Automotive Division, Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce*

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Your great organization and the bureau which I have the honor to represent here have much in common. Both are engaged in efforts to stimulate the construction and maintenance of highways throughout the world. The Bureau of Foreign and Domestic Commerce, through its foreign offices, of which there are sixty, with commercial attaches and trade commissioners in charge, and more than 400 consular officials of the Department of State, is engaged in promoting American industry in general, and has a special interest in the promotion of highway development in foreign countries. In addition to the bureau's representatives at fixed stations, traveling trade commissioners who are specialists in their lines, furnish the bureau with the latest information and data on world marketing conditions and opportunities for the expansion of our export industry, not the least of which is the opportunity for the sale of road building materials and machinery.

The bureau maintains 34 district offices and 46 cooperative offices located in strategic cities of the United States, through which direct contact is kept with American industry and through which foreign trade information and opportunities are made available to American industry.

There was a time in our history, before the advent of the motor vehicle, when the subject of roads was considered of local importance only. In 1893 the governor of one of our most progressive central states appointed a commission to study the subject of road improvement. At that time, the railroads had reached a high state of development, branch lines were being rapidly constructed, connecting the small towns and villages with the larger urban centers of population. This modern method of transportation had put out of use the Conestoga wagon and the canals had dropped into disrepair because they had been superseded by the iron horse. The commission completed its laborious investigations and made its recommendations to the governor. These, in substance, read as follows: "It is recommended that the state maintain a masterly inactivity in the matter of roads as they are of local importance only." What a far

THE AVENIDO QUINTANA IN SAN LUIS, ARGENTINA. CONSTRUCTED OF ASPHALTIC CONCRETE WITH AMERICAN METHODS AND MATERIALS AND BY AMERICAN ENGINEERS AND CONTRACTORS.

cry from 1893 to 1930, even though the years have been few. Not only are roads of more than local importance now, but they have become of county, state, national and international importance.

### INTERNATIONAL HIGHWAY MEETINGS HELD.

During the past few years numerous conferences, conventions and congresses on highways have been held that are of an international character. The First and the Second Pan-American Congress of Highways were held at Buenos Aires, in Argentina, and at Rio de Janeiro, Brazil, in 1925 and 1929, respectively. The Inter-American Highway Conference was held in Panama in 1929. The First and the Second Pan-American Congress were attended by representatives of the Latin American countries and the United States, and the Inter-American Conference, by representatives of the United States and the Central American countries interested in the construction of an Inter-American highway known as the Pan-American Highway.

The First International Pacific Highway Conference was held in Los Angeles in October of this year, under the auspices of the Automobile Club of Southern California, and was attended by a large number of governors and other delegates from the western states of Mexico, interested in planning for a highway to connect Southern California with Mexico City. The governments of the United States and Canada are considering the feasibility of constructing a highway to connect Alaska and the Yukon with a route to the United States through British Columbia.

The Congress of the United States appropriated the sum of $50,000 to provide technical assistance to the Latin American countries for the purpose of a preliminary survey for the Pan-American Highway. Three American engineers are now engaged in this survey, having started work in Panama, and are progressing northward through the Central American states. Mexico has an extensive system of highways under construction, though she is concentrating for the time being on the work of completing the Laredo-Mexico City section of the Pan-American Highway and the highways to Vera Cruz and Acapulco from Mexico City, the first named of which will provide international connections.

### ROAD BUILDING IN EUROPE AND AFRICA.

In Africa they are planning a highway of the future which will reach from Capetown, Union of South Africa, to Cairo, Egypt. A great many miles of this "Great North Road" have already been constructed, in a way, in the different states and provinces through which it will pass. Connections need to be made and bridges constructed on the southern end, while in the sections traversing Egypt and the other northern countries, much more needs to be done before the road becomes a reality.

Hungary, during the last year, has completed the construction of a modern highway between Budapest, the capital, and Vienna, Austria. Austria is now building a new road across the Glassglockner Range of the Alps, which will connect the provinces of Salzburg on the north with Corinthia on the south, and furnish a through means of communication with Italy. An organization in Germany, known as "The Hafraba" is planning the construction of a super-international highway to connect many of the larger cities in Germany with the Autostrade in northern Italy.

Venezuela has been busy building a road from Caracas to the Colombian border near Cucuta, where it connects with a road that Colombia is endeavoring to complete to Bogota, the capital. It is now possible, in dry weather, to travel by motor car from Santiago, Chile, to Buenos Aires, Argentina. The Chilean end of this road passes over the Andes Mountains and is being improved rapidly.

The Famous Central Highway of Cuba, Rising into the Hills Near Matanzas. Constructed of Asphaltic Concrete Under the Supervision of American Engineers by an American Contracting Firm. This Highway, 700 Miles Long, Cost $110,000,000 and Comprised the Largest Single Asphalt Road Contract Ever Let in the History of the World.

Italy is spending large sums of money to reconstruct her state highway system and to provide a means of unemployment relief. Roumania recently has called for bids for constructing several of her main highways. Greece has planned the construction of a system of main highways to cost approximately $30,000,000. Many other countries also are increasing their annual highway expenditures as rapidly as their finances permit.

## Sixth International Road Congress.

The culminating international event in highway educational congresses was the recent Sixth Session of the Permanent Association of Road Congresses, held in Washington under the auspices of the United States Government, where several hundred delegates from more than sixty foreign countries were brought together for a common discussion by engineers and technicians of ways and means to promote better methods of road construction. Traffic control and allied subjects are common to all countries, irrespective of locality. It is thought that this meeting of foreign highway builders and engineers with the most representative of our own highway officials and engineers will do much to further the development of road systems throughout the world.

Nearly three hundred of these men were taken on three highway tours by the Highway Education Board, through different sections of the country. Of these tours they were afforded an opportunity to see the actual construction and maintenance of our many types of highways, to observe the use of modern machinery and to visit a great many industrial plants engaged in manufacturing machinery and motor vehicles, as well as many other industrial phases of the sections of the country through which they passed.

It is our thought that these internationally minded highway engineers returned to their respective countries with an increased knowledge of the economic benefits to be derived from the construction of an adequate highway system, benefited by the discussions by able technicians of the most modern methods. Through this international meeting an impetus will be gained no doubt in the campaign for suitable roads for every purpose that will provide for a more rapid expansion in the use of motor transportation.

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PRESIDENT LAW: I am sure we are all glad to have Major Root's message, and we certainly thank him for coming to Memphis to participate with us in this conference. Gentlemen, I have a letter to read here in this connection from one who had been invited to address the meeting but unfortunately found it impossible to be here. It is from John R. Fordyce, Colonel of Engineers, U. S. Army Reserve Corps. His letter is addressed to Mr. C. C. Lakin, one of the directors of The Asphalt Institute, and reads as follows:

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November 28, 1930.

Mr. C. C. Lakin,
Peabody Hotel,
Memphis, Tenn.

Dear Mr. Lakin:

Many thanks for your kind invitation to address The Asphalt Institute. As I wrote you it will be impossible but it has occurred to me that it would be appropriate to have you read, in my behalf, this communication:

"To the Asphalt Institute.

Gentlemen:

In the deliberations of your body at Memphis it seems most appropriate that you should consider the use of asphalt in connection with the facing of levees, to prevent erosion of the flood waters and wave action. I believe that a flexible coating of asphalt could be placed on the river side of the levees which would be of great service in protecting the levees.

It is my suggestion that engineers of your organization confer with the U. S. engineers who have charge of the river work with a view to finding out the requirements of this work and instituting experiments which would lead to the use of asphaltum in this protective work. It is also my suggestion that you investigate the possibilities of using a woven wire mesh fabric of appropriate strength and that this fabric be coated with asphalt of sufficient thickness to resist water erosion. I believe a coating should be flexible for a long period of time so that it could accommodate itself to the inequalities of the river bank, that it be anchored firmly to the crest of the levee, that it be weighted sufficiently at its lower end to prevent the rolling-up action of the current and that sheets of re-enforced asphaltum be joined and lapped so that the water would not get in between them to roll-up this surfacing.

I have made these suggestions hoping that some cheaper and more efficient means can be devised to protect the face of the levees."

Respectfully submitted,

JOHN R. FORDYCE,

Colonel of Engineers, U. S. O. R. C.

PRESIDENT LAW: I think this letter is very appropriate and it fits in with what has already been done. I believe this brings us practically to the close of the morning session, unless there are some announcements.

MR. C. S. LEE, New York City: Mr. President, I have a motion to make at this time, if it is in order. That motion is that a committee on resolutions be appointed for this conference, to meet at the conclusion of the afternoon session today, in this room, and that the chair appoint on that committee, Mr. A. K. Vickery, city engineer, Denver, Col.; Mr. George W. Craig, consulting engineer of Chicago; Maj. B. P. Root of the Highway Section, Department of Commerce, Washington, D. C.; Mr. W. B. Fowler, city engineer, Memphis, Tenn.; Mr. Norman M. Blaney, director farm-to-market roads, American Farm Bureau Federation, Chicago, Ill.; Mr. V. L. Ostrander of New York City; Mr. C. N. Conner, American Road Builders' Association, Washington, D. C.; Mr. C. S. Lee of The Asphalt Institute, New York City; Mr. Harry L. Howe, city engineer, Rochester, N. Y.; Mr. B. P. McWhorter, state highway engineer of Georgia, Atlanta, Ga.; Mr. William N. Carey, chief engineer, St. Paul, Minn.; and Mr. J. T. Pauls, United States Bureau of Public Roads, Washington, D. C.

PRESIDENT LAW: Is there a second to the motion made by Mr. Lee?

The motion thereupon was seconded by B. P. Root and C. N. Conner and having been voted upon, was declared to be carried.

# SECOND SESSION

## HOTEL PEABODY, 2 P. M. TUESDAY, DECEMBER 2, 1930

## R. H. BAKER, STATE HIGHWAY COMMISSIONER OF TENNESSEE, PRESIDING

CHAIRMAN BAKER: Gentlemen, the session will now come to order. By way of explanation I would like to say that I might have known that Bill Fowler would have pretended to misunderstand the statement I made this morning with reference to the asphaltic types of pavement which you may find in this area. I intended to convey the information that the Tennessee Department of Highways, on its state highway system, does not have in this area a great deal of the late asphaltic types of construction. However, we do have in this state, principally in the middle and eastern parts of Tennessee, slightly under two thousand miles of the asphaltic types of roads. We feel that, with the aid of other states and agencies interested with us in the development of surface treatment and retread construction, we have obtained some very satisfactory results. To those of you who find it convenient, we would consider it a privilege to conduct you over some of these sections. If you will communicate with Mr. Fowler or with Mr. McEwen, the state highway engineer of Tennessee, or with me, we will be glad to arrange any trips that you would like to make through any part of the state, as soon as these sessions have been concluded.

After several years of experience in highway work, I am convinced that no state highway department—basing that statement on Tennessee—could possibly finance highway construction so as to conform to the demands of all the people, regardless of the importance of the road involved from the state or interstate standpoint. Each particular mile of road is the most important road in the world to someone. The adoption of the type and standard to which a road should be improved, therefore, cannot be left with the people who are promoting or pushing or pulling for that particular development. This forms one of the most important problems facing the state highway administrations.

The first paper on this afternoon's program,—that of "Adapting a State Highway System to Local Conditions" deals, I imagine, largely with that subject. It is presented by Mr. J. J. Forrer, state maintenance engineer of the Virginia Highway Department, who, I am advised, has been with his department for a number of years, first in the capacity of division engineer and now in his present capacity as state maintenance engineer. Virginia has done a great deal of work along this line and I know that we are all very much interested in Mr. Forrer's paper.

# Adapting a State Highway System to Local Conditions

**By J. J. Forrer, Richmond, Va.**

*Maintenance Engineer, Virginia State Highway Department*

The State of Virginia has an area of 42,627 square miles and is subdivided into 100 counties. The 1930 census shows a population of 2,421,851. The industries of the state are widely varied. Truck farming is carried on extensively in the coastal plain, the products being potatoes, strawberries, peanuts and green vegetables. Tobacco and cotton are grown in the Piedmont section, while wheat, hay, corn and apples are raised in the valley and upland areas. Stock raising is carried on successfully in the western section, where, due to the growth of blue grass, it is possible to export cattle direct from the pastures. The mining industry provides coal, iron and manganese, and even some gold at times.

Due to its geographical location and its labor conditions Virginia is rapidly becoming a manufacturing state, the principal products being cigarettes, cotton cloth, rayon, shoes, etc. Many plants are operated electrically, the power being generated by hydro electric plants. Virginia also is noted for her sea food. In the Chesapeake Bay and the tidal rivers are to be found the largest oyster beds in the world. The summer resorts, both along the seashore and in the mountains, are famous. Due to the mild climate, geographical location, points of historic interest, natural scenery and to her good roads, Virginia today is enjoying a large tourist traffic.

## HISTORY OF VIRGINIA HIGHWAYS.

History tells us that as early as 1745 Virginia was making an effort to build roads. It is said that George Washington located some of the highways. These roads were straight and were constructed mostly of stone or planks, while the bridges, many of which are still standing, were beautiful stone arches. Between 1845 and 1859 the state issued $30,500,000 worth of bonds for building canals, railroads and turnpikes, $5,000,000 of this being for turnpikes alone. Colonel Crozet, a Frenchman, was one of the engineers at the time and his work is the marvel of engineers today. The war between the states, however, wrecked this program.

THE ROTARY BROOM ATTACHMENT SHOWN ABOVE PROVIDES A SIMPLE AND RAPID MEANS OF CLEANING THE SURFACE PREPARATORY TO APPLYING THE PRIME COAT.

The present State Highway Commission was established in 1906, state aid being given to the counties to the extent of $9,000,000 over a period of 12 years. In 1918 a state highway system of 3500 miles was established. Additions since 1918 have brought the mileage up to 7,132 miles. The entire system is under continuous maintenance, and only in the early spring is there any inconvenience to traffic on the unsurfaced sections. The total road mileage of the state is approximately 59,000 miles. It is estimated that the state highway system of 7,132 miles carries 75 percent to 80 percent of the traffic.

Virginia's method of financing her state road program briefly is by a direct appropriation made by the Legislature, three and one-half cents of the five cent gasoline tax, convict labor, Federal aid and the automobile license tax. The average revenue for construction and maintenance during the last four years has been approximately $15,000,000 per year. The counties finance the construction and maintenance of their roads with a direct county road tax and one and one-half cents of the gasoline tax. Their roads are under the supervision of a board of supervisors and in some instances by a county engineer. At present the State Highway Commission only acts in an advisory capacity.

The mileage, by types, of the state highway system today is approximately as follows:

### Treated Surfaces.

2260 miles of surface treated sand-clay, soil, gravel, etc.
1080 miles of surface treated macadam.
143 miles of cold mixed-in-place macadam.
877 miles of penetration macadam.
39 miles of rock asphalt.
3 miles of bituminous concrete.
771 miles of concrete.
28 miles of sheet asphalt.

### Untreated Surfaces.

200 miles sand-clay, soil and gravel.
546 miles graded.
1085 miles unimproved. These unimproved roads are conditioned for maintenance by widening and by the application of local surfacing material on places that give trouble during wet weather.

7132 miles—Total. (4430 bituminous types; 771 concrete; 746 untreated; 1085 unimproved.)

An analysis of the above type tabulation shows the following conditions: 77 percent, or 5,500 miles, of the state system is surfaced. Of this 5,500 miles of surfaced highways 38 percent are macadam types, 41 percent are surface treated earth types, and 21 percent all other types.

### One Course Bituminous Macadam.

The policy of the Virginia Department of Highways has been to build to the needs of the traffic in each locality, selecting the type of surface to fit the use of the local materials available. This is done with the idea that, if in future years the traffic conditions demand it, the present types may be used as a base for higher-type surfaces. This method of stage construction has allowed a much greater mileage to be built. Naturally it is approved by the traveling public. It has developed rapidly the roads that do the local people the most good and at the same time it has served the tourist.

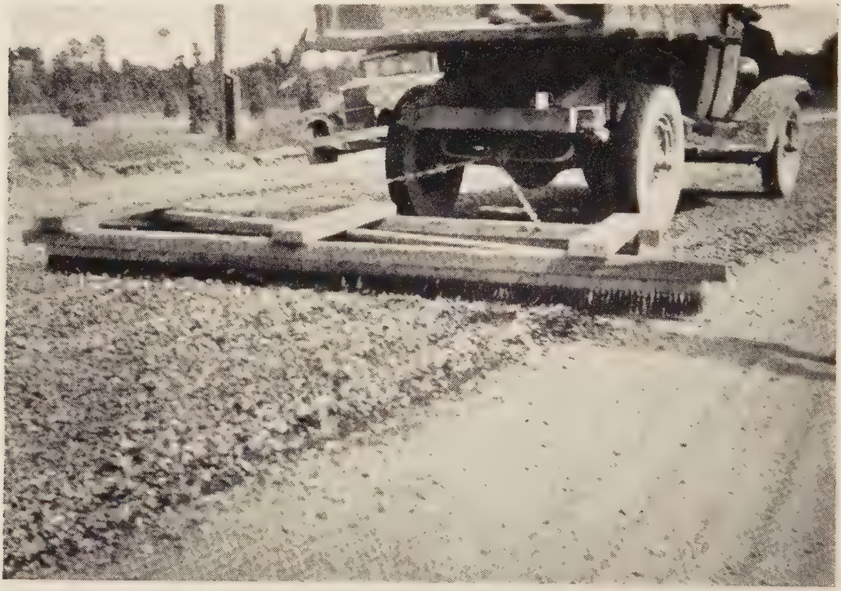
In this "stage construction" a very interesting and economical type of road has been developed known as "one course bituminous macadam." Limestone, granite, traprock, and sandstone are found fairly well distributed over the western and northern areas of the state. Any of these stone work well in the "one course macadam" type.

Road Cleaning Equipment, Showing Broom and Blower Mounted on a Fordson Tractor. The Blower Removes the Dust that has not been Entirely Swept Off by the Broom.

The method of constructing the "one course macadam" is as follows: Broken stone, one inch to four inches in size, well graded, is spread evenly to a thickness of about 10 inches on the subgrade and compacted to eight inches, with a ten-ton roller. Considerable care is taken at this stage of construction to secure a smooth, even surface. Dust, screenings and water are then applied until the voids are filled. After a final rolling the road usually is thrown open to traffic for a few days only. The surface then is cleaned and a surface treatment of bituminous material is applied in two applications of one-third of a gallon to the square yard each, with about 15 to 20 pounds of stone chips spread after each application. The chips are dragged with a broom drag to insure an even distribution and to eliminate small depressions and then are rolled. The average contract price bid for this type of pavement is 90 cents per square yard, exclusive of the surface treatment. The surface treatment cost averages about 20 cents per square yard.

Many advantages have been found in this type of construction. First, only one graded size of stone, exclusive of dust and chips, is necessary to complete the road. This phase allows a much greater crusher output and less handling of material. Second, less skilled labor and expensive equipment are necessary for the work. Third, progress in construction is more rapid, thus making the road available for traffic sooner.

Other advantages are that as depressions occur (and they always do), because of subgrade settlements, these are easily remedied by patching, a more satisfactory process on this type of road than on some of the higher types. Also, in later years, should traffic increase, this type of road can be used as a base and a higher-type top laid over it. Higher-type tops always are more satisfactory after all settlement in a base has been eliminated. Although some sections of this type of road have been in use for six years with very heavy traffic it has not yet been considered necessary to use a higher-type top. The maintenance still is very economical and riding on the roads is comfortable and smooth. It has been found that a thickness of eight inches is ample for carrying present day traffic.



A Drag Made from Stable Brooms. Home Made Equipment, Indeed, but Very Effective in Providing a Smooth Surface.

## Surface Treated Soil, Gravel and Sand-Clay.

Another very interesting type of construction extensively used in Virginia is the bituminous surface treated soil, gravel and sand-clay roads. In our state sand-clay, soil and gravel are found in the eastern section while in the western section certain localities produce creek gravel, chert and shale. Bituminous surface treatments on all of the above materials have proved most satisfactory.

The selection of materials to form the foundation for a stable surface is very important. Local materials should be observed closely as to their action under traffic in order to see whether or not they compact, and, after they consolidate, to see whether they rut or muck in wet weather. The stability of the road does not depend so much upon the size of the larger aggregates as it does upon the cementing qualities of the binder material in the mixture.

A Non-Skid Surface Treated Asphalt Macadam Road. Safe, Durable and Economical, Both in First Cost and Maintenance.

In making our bituminous surface treatments it has been found economical to use local creek or washed bank sand where available for covering material. This is true especially in making the original treatment. By using a bituminous material of "medium curing" qualities no difficulties have been experienced with the sand covering. Where local covering material is not available stone or slag chips and washed gravel are used with a "rapid curing" bituminous material. The covering material, regardless of kind, is dragged with a broom drag in order to obtain a uniform distribution and level up small depressions. The covering material is applied at the rate of from 30 to 50 pounds to the square yard and the coarser aggregates always are rolled. The bituminous material usually is applied in two applications of one-third of a gallon to the square yard.

## Use of Rapid-Curing Material.

These first treatments seldom give trouble within a year and in many cases they have stood up well through two winters. Should depressions occur which would cause a car to swerve at high speed, the road is scarified and reshaped prior to the second-year surface treatment. This operation has proved advantageous and surfaces that have been handled in this way have remained smooth for several years and appear to be good for some time to come. The subsequent surface treatments usually are made with a "rapid curing" bituminous material, applied at the rate of one-third of a gallon to the square yard and covered with from 25 to 35 pounds of chips, gravel or slag. Hot bituminous materials have been used to some extent and have proven very durable, but they are not so easily applied under variable weather conditions.

STATE ROUTE NO. 38 IN VIRGINIA, SHOWING THE ROAD BEFORE IT WAS IMPROVED WITH SURFACE TREATED ASPHALT MACADAM—DUSTY IN THE SUMMER, RUTTY IN THE WINTER AND IMPASSABLE IN THE SPRING.

The cost of the above types of earth roads varies with the availability and kind of local materials. The cost of the soil and sand-clay types is approximately $1500 to $2000 per mile for a compacted surface 20 feet wide and 10 inches thick. The first bituminous surface treatments cost from $1500 to $1700 per mile.

From the mileage used in Virginia it is patent that this type of road is looked upon with favor both by the public and the State Department of Highways. These roads are not temporary make-shifts as is so often considered. This method of construction is giving the people in the outlying districts dustless and mudless roads many years before they could possibly get surfaces of a more costly type.

The first attempt at surface treating an earth road in Virginia in 1924 met with a storm of protest. Fortunately the results were satisfactory and for once in road history criticism has turned to praise. Maintenance costs of the bituminous surface treatments vary according to the amount and weight of the traffic. A fair average, however, is two cents per square yard per year. Subsequent treatments, at intervals of four years, cost eight cents per square yard. Dust laying oils have not as yet been extensively used in Virginia.

### Special Equipment for Surface Treatments.

Large programs of surface treatment compelled the Virginia Department of Highways to develop equipment for the purpose of cleaning the surface ahead of the bituminous distributor. After many experiments it has been found that an eleven-inch blower, with a nozzle extending to the road surface, attached to the back of a light tractor is most satisfactory. Attached to the front end of the same tractor is a rotary broom. One trip over the surface usually is sufficient to remove any dust that would cause the bituminous material to ball or curl. It is estimated that this equipment reduces the cost of cleaning a road 50 percent compared to other methods.

State Route No. 38 in Virginia, Showing the Same Road, at the Same Location and in the Same Season, After Improvement with a Year-Round Usable Surface of Asphalt Treated Macadam, an Asset now Instead of a Liability.

Chip spreaders also have proven economical and satisfactory. Uniform distribution of material is secured and costs in handling are reduced about 25 percent. There also is a considerable saving in material, due to the elimination of losses by using large stock piles instead of small ones. Where the hauls on the bituminous material are long it is found to be of considerable advantage to use hauling tanks instead of sending the distributor to the tank car each time for loading. These hauling tanks are mounted on light high-speed trucks and, by operating this equipment properly, it is possible to keep the application operations in almost continuous action.

In a paper of this kind it is necessary to eliminate many interesting details in connection with the road program in Virginia and the methods of construction used. However, several outstanding facts have been indicated as above: First, the people are provided with improved roads at less cost by using available local materials instead of waiting for the so-called high-type, high-cost construction. Second, more funds are left available to build high-type roads in congested areas where they are most needed. Third, by using stage construction the entire cost of the high-type surface does not become a burden on the present generation.

CHAIRMAN BAKER: Mr. Forrer's paper covers every phase of the subject. Does anyone have a question to ask or a matter to present along this line? Mr. Forrer's paper seems to have been complete in very detail and there is no discussion. The next paper deals with the subject of "Simplified Specifications for Asphaltic Materials," and will be presented by Mr. E. F. Kelley, chief of research for the United States Bureau of Public Roads. I assume that Mr. Kelley needs no introduction and I will ask him to come forward. Gentlemen, Mr. Kelley.

# Simplified Specifications for Liquid Asphaltic Materials

**By E. F. Kelley, Washington, D. C.**

***Chief, Division of Tests, U. S. Bureau of Public Roads***

One part of the program of cooperative research in low-cost road improvement, which is being conducted by the U. S. Bureau of Public Roads and the asphalt industry, concerns the proposed simplifications and standardization of specifications for the liquid asphaltic products known as road oils and cut-back asphalts. This is the second progress report on this portion of the cooperative program, the first having been made by Mr. Prevost Hubbard in the paper which he presented last year at the Eighth Annual Asphalt Paving Conference, held at West Baden Springs, Ind. During recent years the specifications and methods of testing for the semi-solid asphaltic road materials have become fairly well standardized. Comparisons of similar materials used in different localities have been greatly simplified and the reduction which has been effected in the number of grades of material has benefited both the producer and the consumer.

A similar condition does not exist in the case of the liquid asphaltic road materials. The great number of different specifications for materials intended for similar purposes has created a condition which is little short of chaotic. The complete lack of agreement regarding the tests required, the methods of testing used and the test results specified, has created an unnecessarily large number of grades of material. If he is to supply the market, the producer must manufacture and stock the unnecessary grades at additional expense. Otherwise he must eliminate desirable competition by abandoning a part of the business field to other producers. The direct or indirect costs of either procedure necessarily are a charge against the consumer. But this is not the only unfortunate phase of the existing situation. The non-uniformity encountered in the required tests and in the methods of testing are such as to make it impossible, not only for the engineer but even for the expert in bituminous materials, to make any adequate comparison of different materials on the basis of specification requirements.

### Low Cost Road Development Still Experimental.

The development of effective low cost roads, in which the liquid asphaltic products are used so extensively, still is in the experimental stage. It is advantageous at any time to be able to communicate to others the results of experience but it is desirable particularly, in this development stage, that there be the fullest opportunity for the exchange of information resulting from experimental work. The mutual advantage which might be gained, at present, is too often effectively prevented by the non-uniformity of specifications, which make it impossible for one state to compare its results with those of another.

As a preliminary step in the cooperative simplification program, a total of 125 different specifications for road oils and cut-back asphalts for hot or cold application were assembled and the various test requirements tabulated. An analysis of the requirements of these specifications furnishes convincing proof, if any is needed, of the confusion which now exists. Of these 125 specifications, originating in 33 states, 88 are for fluid materials for cold or warm application and 37 are for fluid materials for hot application. The following examples are illustrative of the present difference of opinion as to the requirements of an adequate specification.

One state depends entirely upon a single test, the determination of specific viscosity, for controlling the quality of one of these materials. In other states as many as 13 separate and distinct requirements must be met before a material is considered suitable for acceptance. Forty-four of the 125 specifications do not require the determination of specific gravity. Fifty-four require the specific gravity determination to be made at 25° C. (77° F.) and 27 require it to be made at 15.5° C. (60° F.). Ninety-one specifications require a flash point determination while 34 do not.

### Variance in Testing for Consistency.

For the materials for cold or warm application a few specifications have no requirements as to viscosity. The remainder specify either the Engler or Saybolt-Furol test. Six different temperatures are specified for the Engler test and four for the Saybolt-Furol. The consistency tests specified for the materials for hot application are equally varied, and, in addition to the Engler and Saybolt-Furol viscosity tests, include also float tests and the penetration test. To make any comparison of the results of all these different consistency tests would tax the resources of a technical expert. Ninety-three of the specifications include the solubility test either with carbon disulphide or benzol, while 32 omit this test. Seventy exclude the determination of bitumen insoluble in naphtha while the remaining 55 specify both 86° Baume and 76° Baume naphtha.

The oven test to determine loss on heating is omitted in some specifications and included in others. Some require the test to be made at one temperature and some at another. The distillation test is required in 24 specifications and omitted in the remainder. At least three methods of test are employed. Among those employing the distillation test, there is no agreement regarding the tests to be made on the residues. Variations of a similar character apply also to the requirements for per cent of bitumen of a given penetration, ductility tests on residues, determination of fixed carbon and paraffin scale and solubility in carbon tetrachloride. These examples are based on the analysis of specifications originating in only 33 of the 48 states. Moreover, the variations in practice which have been mentioned relate only to methods of test and not to test limits, concerning which there is an equal or greater divergence of opinion.

It is evident that the existing situation demands improvement. Its disadvantages have been recognized rather generally and in several instances a certain degree of improvement already has been effected through the cooperation of adjacent states and producers serving the particular territory. However, until this time there has been no concerted action by all of the states. It now is proposed to secure the nationwide cooperation of consumers and producers in an effort to simplify and standardize the specifications for the liquid asphaltic road materials.

### Nature of Simplification Program.

The simplification program divides itself naturally into two parts: first, the simplification and standardization of the form of specifications by the adoption of a limited number of tests and the elimination of variations in test procedure; and second, a reduction in the number of grades of material through agreement on the test limits to be specified. The first objective, that of standardization of the form of specifications, necessarily is the primary consideration for the present. Until some agreement shall have been reached regarding the tests themselves, little can be done toward reducing the number of grades of material. But a considerable amount of work must be done before even this first objective can be attained.

It is necessary first to establish a basis for the comparison of the great variety of specifications now in use. Without such a basis of comparison it is, at present, difficult or impossible to interpret the specifications of one state in terms of those of another, even for materials which may be essentially the same.

### Recommended Series of Tests.

To furnish this basis of comparison a definite test procedure for the examination of all liquid asphaltic products has been proposed. This scheme of analysis serves a double function in that it is also the initial proposal for a standard system of tests. The recommended series of tests for all liquid asphaltic products is as follows:

(1) Flash Point.
    a. Cleveland open cup for all products having a flash point above 175° F. (79.4° C.), A. S. T. M. Standard Method D 92-24.
    b. Tagliabue open cut for all products having a flash point of 175° F. (79.4° C.) or less. (This method has been approved by the Bureau of Explosives, for such products.)
(2) Specific Viscosity (Engler)
    Method No. 54, American Association of State Highway Officials.

  - a. At 77° F. (25° C.) for dust layers, primers and all products which are applied without warming.
  - b. At 122° F. (50° C.) for all products, including cutbacks, which should be slightly warmed before application.
  - c. At 212° F. (100° C.) for all highly viscous products which must be heated to approximately 200° F. (93.3° C) or above, before application.

(3) Distillation (For all Products)

A. S. T. M. Standard Method D 20-28T with the following exceptions:

Sample distilled shall be 200 c.c., the weight of this volume to be calculated from specific gravity at 60° F. (15.5° C.).

Bulb of thermometer shall be immersed to a point ¼ inch above bottom of flask. Condenser shall be water cooled. Distillate shall be collected in 100 c.c. graduated glass cylinders and volume per cent off shall be recorded for every 18° F. (10° C.) starting with 212° F. (100° C.). Distillation shall be stopped at 680° F. (360° C.) and the residue shall be immediately poured into the standard penetration containers and allowed to cool for further tests.

(4) Tests on Residue from Distillation

  - a. Float test at 122° F. (50° C.) on all residues of over 300 penetration at 77° F. (25° C.). Float tests at 122° F. (50° C.) of less than 25 seconds are not recommended.
    A. S. T. M. Standard Method D 139-27.
  - b. Penetration at 77° F. (25° C.) on all residues of less than 300 penetration.
    A. S. T. M. Standard Method D 5-25.
  - c. Ductility at 77° F. (25° C.) on all residues of less than 300 penetration, at 77° F. (25° C.).
    A. S. T. M. Tentative Method D 113-26T.
  - d. Solubility in carbon disulphide—all residues.
    A. S. T. M. Standard Method D 4-27.

It should be noted particularly that it is not the purpose of the distillation test, as specified, to produce a residue which, for cut-back products, necessarily will have physical and chemical properties identical with those of the base materials used in manufacture. Neither is it the intention that specifications shall require the determination of the amount of distillate for every increase in temperature of 10° C. (18° F.). It is believed, however, that the frequent determination of the amount of distillate will supply needed information relative to the volatile properties of the great number of grades of material now being furnished for highway work and thus make available some of the data necessary to show essential differences between materials. It is anticipated that with the aid of these data such specification requirements may be established for the distillation test as will be indicative truly of the essential qualities of the various materials. It has been suggested tentatively that for specification purposes the determination of the percentage of distillate at four temperatures may be sufficient.

### METHOD OF CONDUCTING COOPERATIVE CAMPAIGN.

As a first step in the proposed program of simplification it is proposed that during the next year each state highway department shall analyze all fluid asphaltic products purchased for highway construction, not only to determine compliance with its own specification requirements, but also in accordance with the common scheme of analysis outlined above, or with such modifications of the scheme as may seem desirable. This procedure may be expected to develop the basic information which is required before the actual work of standardization can be undertaken actively. It will also result in a thorough trial of the proposed standard system of tests.

For convenience in carrying on the cooperative program the country has been divided into five regions. This division has been made on the basis of sales territories of the principal individual producers or groups of producers. The states in each region are shown in the following table.

| REGION NO. 1 | REGION NO. 2 | REGION NO. 3 | REGION NO. 4 | REGION NO. 5 |
|---|---|---|---|---|
| Maine | New York | Michigan | Kentucky | Montana |
| New Hampshire | New Jersey | Indiana | Tennessee | Wyoming |
| Vermont | Pennsylvania | Illinois | Alabama | Colorado |
| Massachusetts | Delaware | Wisconsin | Mississippi | New Mexico |
| Rhode Island | Maryland | Minnesota | Arkansas | Idaho |
| Connecticut | Ohio | Iowa | Louisiana | Utah |
|  | West Virginia | Missouri | Oklahoma | Arizona |
|  | Virginia | North Dakota | Texas | Nevada |
|  | North Carolina | South Dakota |  | Washington |
|  | South Carolina | Nebraska |  | Oregon |
|  | Georgia | Kansas |  | California |
|  | Florida |  |  |  |

It is proposed to hold a series of regional meetings at a convenient point within each of the five groups of states, these meetings to be attended by representatives of the state highway departments and the principal producers of asphaltic materials within that territory. The first of these meetings will be devoted primarily to a discussion of the proposed standard system of tests in order that an agreement may be reached regarding the common scheme of analysis which is to be followed in the study of existing specifications. It is hoped that the subsequent regional meetings finally will result in agreement on a uniform test procedure and uniform specification requirements for the principal types of fluid asphaltic road materials. If this hope is realized, a national meeting then will be held for the unification of the proposals resulting from the regional meetings and for final ratification of a simplified procedure. This program is to be initiated at once and it is anticipated that the first of the regional meetings will be held early in 1931.

The several state highway departments have been invited to participate in this cooperative program of investigation and coordination and the hearty response which has been received gives great promise of the ultimate success of the undertaking. The practically unanimous acceptance is indicative of the general recognition of the importance of the problem and the general desire to eliminate the manifest disadvantages of the present situation.

## DISCUSSION.

Mr. Arthur H. Blanchard, Toledo, O.: Mr. Chairman and Gentlemen, I trust that all present fully appreciate the serious economic aspects of the admirable paper presented by Mr. Kelley, to every sentence of which I heartily subscribe. I think that the chaotic condition which exists in the highway departments throughout our forty-eight states, and the fact that millions of dollars are lost to the public every year, is because—and I am going to use an ugly word that is in Webster's dictionary, although you may not like to hear it—your present practice is asinine. Do you realize, gentlemen, that we are approaching the fortieth anniversary of the establishment of the first state highway department? Do you realize that there is a committee of more than eighty men in the American Society for Testing Materials who devote hours upon hours to committee meetings and society meetings and in the promulgation of specifications of materials? And, gentlemen, I speak reservedly, because it made me disgusted during the four years that I was chairman of this committee to have state representatives on that committee go exactly opposite to the things that they had agreed upon as the basis of uniformity and the desirable economic results to be attained thereby. What does it mean to producers of materials to have this conflict of materials and of specifications? It means that special materials must be manufactured by them to meet the great variety of specifications which Tom, Dick and Harry, setting themselves up on high, with wings and a halo, think are supreme, holding that nobody in any other state knows a thing about specifications.

Chairman Baker: As a representative of one state highway department, and I know there are several others represented here, I subscribe fully to every statement made by Mr. Blanchard. I think we have been a bunch of "saps" to go along as we have and let some individual's ideas dictate to us a chaotic condition that should be corrected. With the cooperative organizations that we have at the present time there is no reason why we should not realize the dream that all of us have had for a number of years, and that is the standardization of both materials and equipment. Just as a matter of illustration, let me say that I was checking up the other day with our equipment engineer and he advised me, I believe, that about two years ago our grader blade equipment, in order to give ordinarily a decent service to the graders that we were operating, required a stock of between sixty and seventy thousand dollars worth of blades. Now, with some slight effort, but not entirely coordinated among the different states, it has been possible to establish samples or standards in that one item and, at the present time, though rendering much better service, our grader stock does not exceed $10,000.

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Chairman Baker: The next paper on the program is the "Survey Report of the Stage or Progressive Construction Committee." The report is to be presented by its chairman, Mr. Charles E. Grubb, engineer executive, County Highway Official's Division, American Road Builder's Association, and is to be followed with discussion by Mr. McWhorter and Mr. McEwen.

# Report of the Committee on Stage or Progressive Construction

## By Charles E. Grubb, Washington, D. C.

*Chairman*

Much discussion has been had with reference to stage construction methods employed in street and highway development. These questions naturally present themselves: What is stage construction? Who does it? To what extent has it been used? Is it a success?

A brief reference to the tables showing the character of highways in the United States quickly convinces one of the necessity for considerable study along this line. In the state highway systems there are included 306,442 miles, of which 68,355 miles are improved with penetration macadam, sheet asphalt, brick and concrete, while the remaining 238,087 miles, or 78 per cent of the total, are of unimproved earth, graded and drained earth, top soil, sand-clay, shale, gravel and waterbound macadam. Under the county systems, which also include the district and township roads, we find 2,709,839 miles, of which only 35,186 miles are paved with penetration macadam, sheet asphalt, brick or concrete. The enormous total of 2,675,653 miles, or almost 99 per cent, is composed of unimproved earth, graded and drained earth, top soil, sand-clay, gravel and macadam. Thus it can be seen that with forethought or not, the road building authorities of the country have carried on their work so that,

Stage Construction in Chautauqua County, N. Y. on Sinclairville-Thornton Road. The Gravel Base, with the Coarse Stone Raked Out. The Gravel was Obtained from a Creek Bed.

at the present time, it is all more or less in a stage construction state.

### COSTLY ROADS BUILT WHEN UNNECESSARY.

The above figures, however, do not show the relationship of surfaces to the traffic using them or to the maintenance costs involved in keeping them in proper repair. All too frequently there are found surfaces improved far beyond the needs of the particular location, while there are other roads which are wholly inadequate for rendering proper and needed service. In view of this situation, the organizing committee of the Ninth Annual Asphalt Paving Conference invited a number of engineers to act as a committee to study the whole proposition and report their findings at this meeting. The committee is made up of: Charles E. Grubb, engineer executive, County Highway Officials' Division, American Road Builders' Association, as chairman; B. P. McWhorter, state highway engineer, Georgia State Highway Department; T. C. McEwen, chief engineer, Tennessee State Highway Department; Fred H. Shepherd, engineer of maintenance, Borough of Queens, New York City, and Charles S. Christian, state highway engineer, Arkansas Highway Department.

The questionnaire method of surveying the country was used and the following questions were asked:

(1) Have you designed any of your highways which were initially intended to carry light or medium traffic so that additional improvements can be made without radical change of grade lines, drainage structures and replacements of existing service features? In such cases, what initial type of construction was involved and what widths and thicknesses? What part of the construction work and outlay do you consider as assets in further improvement?

(2) To what extent have you improved the following types of highway: (A) graded and drained earth, (B) sand-clay and top soil mixture, (C) gravel surface and (D) broken stone surfaces, by one or more of the following methods: (a) oiling, (b) bituminous mats, (c) "mixed-in-place" bituminous treatment, (d) penetration macadam wearing course, (e) hot-mix wearing course, (f) cold-mix or other bituminous type or method?

(3) To what extent have you considered coordinated traffic and maintenance data in determining the necessity for such additional improvements and what were the governing factors in influencing your decision? In other words, have you set up any yardstick by which you measure the justification for each progressive stage?

(4) Please outline, in your own way, the experience you have had with the stage or progressive type of construction and the conclusions which you have drawn from your experience thus far.

This questionnaire was mailed to the state highway departments, to the counties of 50,000 population and over and to the cities of 50,000 population or more. Returns were received from twenty-six state highway departments, seventy-three counties and sixty-six cities, a total of one hundred and sixty-five, representing approximately 54 per cent of the states, 18 per cent of the counties and 22 per cent of the cities. The completeness with which the answers were made was most gratifying and a tremendous mass of information was received, with careful descriptions of the methods employed and with discussions of the economic considerations involved. All of the information has been extremely valuable. From the negative information received, as well as from the positive, a number of conclusions may be drawn. The nature of the traffic, the location of the state, the county and the road system and the topography of the surrounding country markedly influence the policy followed.

Stage Construction in Chautauqua County, N. Y. Taking out the Coarse Stone.

In general, the thickly populated states of the East have not followed a stage construction program in entirety. The reason for this is evident when one considers that the automobile problem presented itself all at once after the majority of roads had been laid out in accordance with the traffic needs of the time and that road building and other developments had adjusted themselves to such a layout. Accordingly, when the changed conditions presented themselves under the increasing automobile traffic, it became necessary immediately to place pavements on locations which sometimes were not of the best. Even here, unconsciously, the stage program method was followed to a certain extent, in that old macadam roads were used as bases for new wearing courses. It is in the Middle West, the Southwest and the Far West that the method can be followed completely. To a somewhat lesser degree it can be followed in the thinly populated states of the East, such as the northern New England states and some of the southern states. The majority of the state returns were received from these areas, as is shown clearly on the map. In the mid-western group, which covers a relatively flat country, it has been somewhat easier to lay out a system with a view to stage construction because of the relatively small yardages of grading involved.

## CONSTRUCTION PRACTICE OF THE STATES.

Mr. H. S. Kerr, chief engineer of Utah, in his report, has very aptly defined the trend towards stage construction. He says: "Prior to 1920, the general theory or road improvement in this state was from mud to pavement. Since that time stage construction has been its basis of improvement. Width, line, grade, drainage and structures are basic factors of improvement with the thought that, as required, surfacing *equivalent* to the *earning capacity* of the road can be added."

Of the twenty-six states reporting, twenty-four definitely follow a plan of design, so that, while the immediate traffic increases from light to heavy, additional improvements can be made simply by adding additional thickness of surfacing. They all emphasize the need for carrying on such grading work over the entire system at the earliest possible moment and doing it with the utmost care. The next step is that of adding a stabilizing course, consisting generally of gravel or crushed stone. Twenty-two states report the use of gravel, eleven crushed stone, six sand-clay, top soil and shale and two oiled earth. The latter method has been used with remarkable success in Minnesota and North Dakota, and undoubtedly could be adopted to other areas where non-capillary subgrades are found.

STAGE CONSTRUCTION IN CHAUTAUQUA COUNTY, N. Y. SHOWING PORTABLE CRUSHER BREAKING UP THE LARGER SIZES OF STONE.

It is the consensus of opinion that, as a general practice, whenever a road is graded, granular material should be added immediately and maintained so as to take care of traffic. The adoption of this policy usually will serve the public and postpone the need for expensive types for many years. The depth of gravel employed varies according to local conditions. Two general methods are employed, as follows:

Stage Construction in Chautauqua County, N. Y. Showing Crushed Gravel Piled and Ready for Spreading.

(1) Traffic-bound, where the gravel or crushed stone is mixed with the underlying subgrade and maintained by dragging until stability occurs.

(2) By placing the stone or gravel in a layer and bonding the surface by dragging.

Both methods have been successful and have varied according to the quality of the surfacing material and whether or not earth needed to be added to obtain consolidation. As soon as traffic has reached such a volume that the maintenance costs on untreated surfaces begin to increase, the next step is to apply bituminous treatments. The same number of states above referred to have all carried on this next step. Surface treatments of all kinds have been employed, as well as the two varieties of mixed-in-place surfacing.

### Progressive Construction in Alabama.

Alabama reports all roads during recent years built with great care given to grading and draining. A total of 5,700 miles so far have been graded and drained and 850 miles have been paved. Mr. Finnell reports the progressive type highly satisfactory for 75 per cent of the mileage and says that only 25 per cent requires immediate paving.

CALIFORNIA reports its practice as follows: Initial construction, grading and draining, with the road-bed from 24 to 36 feet, on which is placed a crushed stone or gravel surface 22 feet in width. This surface material almost invariably is treated with oil to prevent loss. By having a 22 foot width of stone or gravel surface, it is easy to construct a pavement 20 feet wide of any type desired at a later period. On well solidified stone or gravel bases, heavy surface treatments approximately one inch in thickness are quite common and have been very successful.

STAGE CONSTRUCTION IN CHAUTAUQUA COUNTY, N. Y. SHOWING CRUSHED GRAVEL PREMIXED AND MANIPULATED.

IDAHO uses a 20 foot width of crushed gravel, usually followed immediately by a mixed treatment with asphaltic road oil.

INDIANA has a large mileage originally constructed with waterbound and gravel surfaces which are now being "stepped up" to carry heavier traffic by placing a "mixed-in-place" wearing course either of crushed stone or crushed gravel mixed with cut-back asphalt.

KANSAS has followed the stage construction method for the past five years, using the "mixed-in-place" sand-gravel and asphaltic oil.

KENTUCKY has more than 1,100 miles of macadam originally constructed for light traffic, subsequently surface-treated and now being further surfaced with "mixed-in-place" types.

MAINE reports a design of grade and line with gravel surfaces, so that, as traffic increases, further paving can be placed without disturbing any of the previous investment.

MINNESOTA is one of the states having particular success with the treatment of natural subgrades, but emphasizes the necessity of having the so-called "high grade line,"—namely, raising the surface of the graded road from two to four feet above the surrounding country so as to lower the ground water level. Treatments on roads, so graded and covered with light gravel, have been very successful and are taking a traffic of from 300 to 1,000 vehicles per day.

### MAINTENANCE COSTS REDUCED IN MONTANA.

MONTANA quotes her practice as grading one year and gravel surfacing the next. As soon as traffic reaches 500 vehicles per day, highway engineers employ either surface treatment or mixed-in-place types in order to reduce maintenance costs.

NEVADA reports that her highway engineers have followed the stage construction policy for the past three years, with grading and draining first, followed by an 18 foot gravel roadway, and then mixed-in-place surfacing as traffic increases.

NEW HAMPSHIRE reports all grades and structures built with a view to future surfacing, except through villages where local conditions make a different policy necessary. Gravel roadways are constructed 20 to 24 feet in width and 6 to 10 inches in depth. Practically all of the gravel surfaces in New Hampshire have been treated with bituminous materials and have given marked satisfaction to the traveling public.

STAGE CONSTRUCTION IN CHAUTAUQUA COUNTY, N. Y. BITUMINOUS TREATED SURFACE MIXTURE AFTER IT IS ROLLED.

In some of the eastern states, notably in NEW JERSEY, where very high concentration of traffic is found, stage construction is followed to the extent of so designing the graded width as to carry three or four lanes of high-type pavement immediately, with an additional provision of wide shoulders which have been treated with bituminous materials and are available for parking for the present and for additional lanes of high-type pavement as soon as the traffic requires, without further grading or draining being necessary.

NEW MEXICO reports that practically all of its system has been built by the stage construction method. The state has 85 miles paved, 500 miles of oil processed gravel, 1,402 miles of gravel and crushed stone untreated and 174 miles graded and drained.

NORTH DAKOTA grades and drains as rapidly as possible and follows with stage construction of the surface as traffic increases.

OHIO reports about 4,500 miles of traffic-bound construction on its system during the past seven years. All unpaved mileage on the state system is of this type. Some of it has passed through the stage of earth, traffic-bound and surface treatment, the latter carrying as high as 2,500 vehicles per day, and then being paved with some high-type pavement. While in some instances these low cost roads have been expensive to maintain under heavy traffic, they have served to take care of the situation until funds for high types were available. And in the vast majority of cases they have served to open to traffic the poorer sections of the state where it will be many years before high types will be justified.

WYOMING reports stage construction policy as standard, first by grading and draining, followed by gravel or crushed stone and then by a mixed-in-place type.

## ADJUSTMENT OF ROAD SURFACES TO NEEDS.

In answer to Question 3, thirteen states declared that they were coordinating traffic needs and maintenance costs. Only one state reported that it did not employ this method of control. There is no question but that a more careful checking will have an important bearing on the scientic adjustment of road surfaces to road needs.

OKLAHOMA reports that its policy is to grade and drain the entire system as rapidly as possible and then by stage construction, to improve such mileage as does not require an immediate pavement of a high type.

OREGON first grades her roads 23 to 26 feet, inside of ditches. Stage construction, by using gravel or macadam, 18 to 20 feet wide, protected with an oil mat, follows as traffic increases. Experiments are being carried on with the mixed-in-place type of construction on the desert soils. Mr. Baldock states: "In our opinion, the stage method of construction, basing changes in type to increase the traffic demands, is a logical procedure. It is required in the development of any kind of transportation system, whether railway or highway. If it were possible to have the requisite vision into the future, its economy and use would be more recognized."

SOUTH DAKOTA reports: "We are designing our grades with high grade line, light curvature and flat vertical curves so that, as traffic demands increase, we can change to progressively higher types. Many miles have been converted from gravel surfacing to asphaltic oil gravel, three inches thick."

TENNESSEE reports that the department has graded and drained along high standards of road-bed. Surfacing, consisting of gravel or crushed stone 4 to 6 inches deep and to a width of 19 feet, then is placed and worked in under traffic. As soon as it becomes thoroughly stable, heavy surface treatments are given and, as traffic further increases, mixed-in-place types are employed.

STAGE CONSTRUCTION IN CHAUTAUQUA COUNTY, N. Y. SHOWING THE SEAL COAT, OF HOT ASPHALT OF 120 PENETRATION MIXED WITH STONE CHIPS, AFTER IT HAD BEEN APPLIED AND ROLLED.

VIRGINIA reports that her highway engineers have followed this practice on approximately 1,900 miles of their system. She further reports designing of road-beds so that grading and draining are done properly with a view to ultimate location. This is followed by placing a gravel surface and then by surface treating. Virginia now is experimenting with "mixed-in-place" wearing courses.

WEST VIRGINIA shows the stage construction policy to be standard practice, except in the few cases where traffic required an immediate surface of high type. The state also advises that this practice in mountainous country allows for settlement of fills without destruction of the surface and, with the low cost surfaces used, permits a gradual strengthening wherever needed, so that a more economic base construction is obtained.

## PRACTICE REPORTED BY THE COUNTIES.

Of the seventy-three counties reporting, forty-eight definitely planned new construction with a view to permanent grading and structures with light types of surfacing for the present, so that heavier surfacing can be added as needed with a minimum of disturbance. Nine counties report oiled-earth treatments; five reported bituminous treatments on sand-clay, top soil and shale; twenty-one reported bituminous treatments of gravel and seventeen reported bituminous treatments of crushed stone. Eighteen endeavor to plan their improvements in accordance with traffic studies, while twenty-one frankly admit that they make no effort in this direction.

Stage Construction in Chautauqua County, N. Y. Showing the Finished Bituminous Surface.

Methods employed in the most progressive counties are quite similar to those used by the states. The counties invariably recommend the adoption of a permanent location with a low cost surface in preference to fewer miles with high type to be built immediately, except in those few cases where traffic demands a high quality pavement at once. They further recommend the immediate stabilization of such graded surface so as to give traffic year-round service. In general, county road widths are approximately 30 per cent less than state widths in the same areas. In the prairie sections, thirty-foot graded roadway widths are obtained as there is very little extra cost above that required for the 22 foot widths.

In the East, particularly in New York, Pennsylvania and some of the New England states, the minimum graded width is that of 22 feet. Emphasis is given to the thought that by such proper location and grading, it is possible to place thin wearing courses, which are well above the ground-water level and which are entirely adequate for the traffic, when the same total amount of money spent on inferior grading and much thicker surfaces would not be anywhere near as satisfactory. This is a most important observation and, while it has been appreciated by engineers, it is only recently that the practice has begun to be carried out on a large scale. Too much emphasis cannot be placed on this matter of spending vast funds for proper grading and draining because, in the long run, such a practice will permit the earliest possible improvement of the entire county system with satisfactory surfaces at the lowest cost.

In the beginning, there may be a year or two, while the grade is settling, that the surface breaks up to a certain extent, but by the end of the third year thin wearing courses of gravel, crushed stone, etc., treated with bituminous materials, will have very definitely established a wearing course that can still be maintained at low cost.

The ingenuity of some of the county authorities in utilizing local materials is worthy of mention. The use of gravel is widespread and the quality of gravels obtained from different parts of the country also varies. One variety, namely known as "creek gravel," has presented some difficulties because of the large percentage of coarse pieces. Squire Fitch, engineer of Chautauqua County, New York, has developed a method which is cheap and effective. Briefly the method is as follows: The gravel is placed in two six-inch layers and, with a raking device, all course particles over two inches in maximum diameter are raked to the side. After compaction of the two fine gravel courses, a portable crusher is hauled down the road and reduces all of the coarse material which previously had been windrowed out. After priming the gravel base, this crushed material is spread over the surface and covered with bituminous material. Then it is manipulated as a mixed-in-place proposition, is finally flattened out and rolled and is sealed with hot asphalt of about 120 penetration. Remarkably smooth and durable surfaces have been achieved by this method. There are many other variations too numerous to mention, but from a survey of the field it would seem that there is hardly an area in the country where a thorough study of local materials will not develop some type of progressive surfacing at very low costs.

## Practice Reported by the Cities.

Eleven cities reported that they followed stage construction methods to a certain degree. However, the situation in the cities is quite different from that found on the rural highways. In general, traffic is present in large volume and high-type pavements must be placed immediately in order to give satisfactory service. In many instances where cities had old gravel or macadam streets they have been able to make them give good service by placing bituminous wearing courses but, as a general proposition, stage construction applies only in certain instances. There are two general methods followed and these invariably are in the suburban areas or in new real estate subdivisions. They are as follows:

(1) Full-width streets are laid out with proper curbs and gutters and either a center section is paved or one-half the width is paved, with the other areas maintained as earth surfaces frequently oiled.

(2.) In the layout of a 20 foot street without curbs, with reser-

### TABLE I.
### NUMBER OF REPLIES RECEIVED FROM QUESTIONNAIRE
(Stage Construction)

| Information | State | County | City | Remarks |
|---|---|---|---|---|
| Questionnaires sent out | 48 | 400 | 300 | Total—750 |
| Questionnaires returned | 26 | 73 | 66 | Total—165—22% |

By states, number received:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Alabama | 3 | Idaho | 1 | Maine | 2 | South Carolina | 3 | W. Virginia | 3 | South Dakota | 1 |
| California | 7 | Illinois | 5 | Massachusetts | 3 | New Hampshire | 3 | North Dakota | 1 | Tennessee | 3 |
| Colorado | 1 | Indiana | 3 | Michigan | 9 | New Jersey | 4 | Ohio | 14 | Texas | 5 |
| Delaware | 2 | Iowa | 9 | Minnesota | 7 | New Mexico | 1 | Oklahoma | 4 | Utah | 1 |
| Dist. Columbia | 1 | Kansas | 5 | Missouri | 1 | New York | 12 | Oregon | 1 | Virginia | 3 |
| Florida | 2 | Kentucky | 3 | Montana | 1 | Nevada | 1 | Pennsylvania | 7 | Vermont | 2 |
| Georgia | 1 | Louisiana | 3 | Nebraska | 2 | North Carolina | 1 | Rhode Island | 2 | Washington | 1 |
| | | Wisconsin | 2 | | | Wyoming | 1 | Miscellaneous | 18 | | |

| | | | | |
|---|---|---|---|---|
| QUESTION 1—Have you designed highways for light traffic with grade to take heavy surface later? | 24 | 48 | 11 | |
| QUESTION 2—Use of the following: | | | | |
| (a)—graded and drained earth | 2 | 9 | 12 | |
| (b)—sand-clay, top soil, shale | 6 | 5 | | |
| (c)—gravel | 22 | 21 | 16 | |
| (d)—broken stone | 11 | 17 | 21 | |
| QUESTION 3—Have you coordinated traffic need and maintenance cost? | Yes 13<br>No 1 | Yes 18<br>No 21 | Yes 2<br>No 14 | |
| QUESTION 4—Outline methods used in following stage construction methods. | Methods<br>10 | 16 | 5 | |

vation in grass plots on either side, so as to provide for extensions and widening in the future.

Many cities report that they have designed their concrete streets with high curbs so as to provide for asphalt surfaces when the concrete becomes worn. Twelve cities report the practice of oiling outlying earth streets while sixteen report surface treatment on gravel and twenty-one on broken stone. Only two cities report the building of a street in accordance with maintenance records and traffic costs. The reason for this is found in the system of assessing the abutting property. Human nature is so constituted that when it pays an assessment it expects to have a pavement that will last indefinitely and it is very difficult to carry on stage construction which requires periodical assessments over a period of years, even though the total cost may be less.

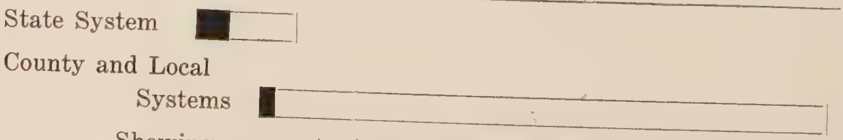
### CONCLUSIONS AND RECOMMENDATIONS.

(1.) A general plan of improvement for the entire area, whether state, county or city, should be worked out and given appropriate publicity. This publicity should set forth the results to be obtained from such planning. Careful budgeting of proposed operations over a period of five years, minimum, and ten years, preferably, is recommended. Such a plan becomes established in the public mind and the addition each year of a certain mileage in accordance with that plan will prevent much of the bickering and lost motion of past years.

TABLE II.

SHOWING CHARACTER OF HIGHWAYS IN U. S. AS OF JANUARY, 1929.

| Kind of Surface | State | County | City |
|---|---|---|---|
| Unimproved | 81,549 | 2,276,840 | No Totals |
| Graded and drained earth | 31,755 | | |
| Top soil, sand clay, chert, shale, gravel | 106,641 | 352,359 | " " |
| Macadam (w. b.) | 18,142 | 46,454 | " " |
| TOTAL | 78 %<br>238,087 | 99 %<br>2,675,653 | " " |
| Other pavements, penetration macadam, sheet asphalt, brick, concrete | 22 %<br>68,355 | 1 %<br>35,186 | " .. |
| Total Mileage | 306,442 | 2,709,839 | " " |



Showing per cent of total mileage improved with high-type shaded in black. Stage construction in white.

(2.) The entire mileage should be graded and drained at the earliest opportunity on permanent location and further development obtained through stage construction methods. Those sections which require immediate paving with high types should be so constructed. All other sections should be developed only in accordance with traffic demands. The advantages of such policy are as follows:

(a) A large annual mileage to satisfy public demand with limited funds.
(b) Utilization of local materials for first stages.
(c) Economy of traffic operation over larger improved mileage —a saving directly to the car owner.
(d) Assurance of greater permanency of final surfacing (as settlements and other weak spots indicated by time and traffic can be repaired or treated prior to placing expensive pavements).
(e) Use of a cheaper or thinner surface.
(f) Low cost surface sufficient for traffic during early period. (Based on experience that traffic increases in volume and unit weight only gradually).
(g) Saving of interest on delayed investment in high-cost types.

(3.) A road-bed, two to four feet above ground-water level, adequately drained, frequently will give first class transportation service with a thin wearing course, when a poorly graded road in exactly the same subgrade will have a high maintenance cost even with three times the thickness of surface.

(4.) This study of subgrade is the most important single item affecting the construction of highways and its importance cannot be over emphasized. All too frequently in past years, design of surfaces has been made with a view to overcoming bad subgrades with heavy pavements and at heavy expense. The correct method is to modify the subgrade to a uniform condition, followed by a wearing course which may be relatively thin and at much lower cost.

(5.) Present cost accounting on maintenance expenditures largely is inaccurate. Standardization of practice is much to be desired and also careful traffic census records, with a view to future design of surfaces in accordance with such records. There is altogether too much talk of maintenance cost per mile, whereas the important figure is cost per vehicle. For example, a stage construction surface may cost $5,000 per mile and have an annual maintenance cost of $500 and a traffic of 500 vehicles per day. Including interest on the investment, there is a vehicle cost of $1.60 per year. Contrast this with a surface costing $20,000 a mile, with a maintenance cost of only $200 and the same traffic. Including interest on investment, however, there is a vehicle cost of $2.80 per year. Furthermore, in the first instance the maintenance expenditures partly are betterments and there is a gradual strengthening of the surface. It is obvious that traffic volume is the criterion of true cost.

(6.) It is recommended that The Asphalt Institute prepare a series of manuals dealing with all types of asphalt construction, written in such a way as readily to be understandable in non-technical language.

(7.) It is recommended that nomenclature as to types and materials be standardized and simplified, with a view to removing the confusion and mystery that, in some instances, has surrounded the subject.

(8.) More contractors should become qualified for handling these low cost surfaces and as much work as possible should be carried on under contract.

(9.) The public should be educated to know that the slipperiness and corrugations found in some old pavements and surfaces are entirely unnecessary in modern construction and that, with present practice, it is possible easily to build not only low cost surfaces but surfaces which are completely non-skid and which possess extraordinarily smooth riding qualities.

(10.) The continued maintenance of gravel, top soil and sand-clay roads in an untreated condition is very uneconomical. The average loss of surface is about one inch of depth per year. To replace this loss with the same material costs more than the surface bituminous treatments, which not only give a higher quality of service but, at the same time, conserve the original thickness of materials.

(11.) There is today, a tremendous mileage of road surface at that point of stage construction where such asphalt treatments will double their carrying capacity at a marked reduction in maintenance costs.

(12.) Stage construction, utilizing bituminous types, is pre-eminently sound practice on a big scale already and should be extended to all sections of the country.

In concluding, I want to acknowledge the help of all those who contributed to this report and to thank them and to express our appreciation of the help that The Asphalt Institute has given, particularly through Mr. Gray of the institute staff.

## DISCUSSION.

**Chairman Baker**: There are two papers discussing this subject. If there is any discussion suppose we have it now, while we are waiting for the lights.

**Mr. Grubb**: Two members of the committee are present and they will offer discussion in order to inspire others to do likewise. Mr. McWhorter, chief engineer of the State Highway Department of Georgia, will tell you of the experience in Georgia.

**Mr. B. P. McWhorter**, Atlanta, Ga.: Mr. Chairman and Gentlemen: Mr. Grubb's paper has pretty fully covered this situation. About four years ago the State of Georgia, realizing that its finances were not sufficient to carry out a large mileage of high-type construction, made experiments with surface treating sand-clay top soils and also surfacing mixtures. We experimented fully, using various types of cut-back asphalts, treating surfaces with "mixed-in-place" construction. We believe after studying this subject fully that we have come to a definite conclusion on which we can write a cut-back specification in order to get the best results obtainable. Our sand-clay surface treatments now are approximately two years old, and we have had very little maintenance.

Our method, which I discussed fully in my paper at the Eighth Asphalt Paving Conference and which described fully the surface treatment, you will remember, was used by both Georgia and Florida. We differ a little, one from the other, in that we use a tar prime in penetrating the top soil or gravel instead of using liquid asphalt for the material. We use what is known as OH2 modified. It is a hot application that we used entirely on limerock construction in both Georgia and Florida. This specification has proved satisfactory. In fact we are entirely pleased with it.

I cannot lay too much stress upon Mr. Kelley's paper about coming to some standard method of testing cut-back asphalt for, from our experience, we in Georgia believe that we can cover the field thoroughly and meet every condition in the state with no more than three types of specifications. We are now starting to prepare a specification that will meet this requirement and that will force manufacturers to give us the best product obtainable. We are going to submit these specifications to the Bureau of Public Roads in the next thirty days and are in hopes of receiving Federal aid on a considerable mileage of surface "mixed-in-place" construction during the next six months.

The asphalt industry in the past, especially on surface mixtures, has been given a black eye because of the use of an inferior product in such mixtures. We have had considerable failures in Georgia, due to our not knowing anything about it. Possibly some salesman would come along promoting a low-grade product and we put it on the road. Sometimes, before we got the job finished, it failed completely. We believe, from our experience during the past few years that we are right. Some of our jobs are now four years old and we have had practically no maintenance. This surface varies from an inch and a half to three inches and is mixed on a 3½ to a 4-inch gravel base. It will carry approximately five to six hundred vehicles a day. As I say, we have had practically no maintenance and, basing our future specifications on these products, we believe that we will be able to write a specification that will confine it to not more than three types which will give us excellent results in every portion of the state.

MR. GRUBB: Thank you, Mr. McWhorter. The second member of the Committee is the chief engineer of the Tennessee State Highway Department, Mr. T. C. McEwen.

MR. T. C. MCEWEN: Mr. Chairman and members of the Conference: I am just going to give you a few minutes of talk with reference to what we have done in surface treating roads in Tennessee. We have treated something like eighteen hundred or two thousand miles. Last year we treated four hundred. This treatment consists of a bituminous surface, eighty pounds, on crushed limestone or gravel. This, placed on a well graded and drained base, is graded to high standards. The base is made up of traffic-bound dry gravel or crushed limestone, on which the surface is placed after two or three years of use. We put down three to four-tenths of prime and we place the crushed limestone or the gravel and squirt the material on that. We use a 12,000 or 14,000 pound grader and turn that over about four or five times. Then it is shaped and rolled. We patch that and we have a finished surface.

Now, this eighty pound treatment has cost us approximately twenty-five cents a square yard. It depends, you know, on how far your material is hauled but that is a good basis for our total cost. We have had wonderful results with this method. The asphalt used in that is a cut-back, in which the asphalt is 80 to 105 penetration and the cut-back agent is thirty per cent.

Chairman Baker: We all appreciate very much this comprehensive report and we realize, of course, the quantity of work involved in preparing it. The next paper dealing with the "Economic Thickness of Foundation and Wearing Course with Reference to Subgrade," is one of the last on today's program. That will be presented by Mr. Roy M. Green, manager of the Western Laboratories at Lincoln, Neb.

# Economic Thickness of Foundation and Wearing Course

*(With Reference to Subgrade)*

### By Roy M. Green, Lincoln, Neb.

*Manager, Western Laboratories, Inc.*

Before entering into a rather lengthy consideration of foundations it would be well to dispose of the less difficult part of this subject, namely, the economic thickness of the wearing course.

The following discussion of the economic thickness of the wearing course is predicated upon the assumption that the wearing surface rests upon a base which is ample to support the traffic loads, whether the base be compacted gravel, macadam, concrete or "black base."

## Stability of the Wearing Course

If the wearing course has this desirable degree of support the determination of its economic thickness becomes a matter of corelating the obtainable stability of a particular type of asphaltic mixture with its

Suggested Economic Thickness of Asphalt Wearing Courses

| Type of Mixture | On Concrete Base | On Gravel, Macadam or Similar Base | On "Black Base" or Binder Course |
|---|---|---|---|
| Asphaltic Mixtures Containing Aggregate up to 10-mesh Size | .......... | .......... | ½ in. to 1½ in. |
| Asphaltic Mixtures Containing Aggregate up to ½ in. in Size | 2 in. to 2½ in. | 2 in. to 2½ in. | 1½ in. to 2 in. |
| Asphaltic Mixtures Containing Aggregate up to 1¼ in. in Size | 2 in. to 3 in. | 2 in. to 3 in. | 2 in. to 3 in. |
| Rock Asphalt Mixtures with Aggregate up to ½ in. in Size | 1 in. to 2 in. | 1 in. to 2 in. | 1 in. to 2 in. |

Note—If a primer coat is applied to the concrete, gravel, macadam or similar base, it is possible to reduce by one-half inch the thickness of wearing surfaces containing aggregate up to one-half inch in size.

It is assumed that when rock asphalt mixtures are used a primer coat first is applied to the base, if the cold process is used.

thickness. That is, there should be some relation between the thickness of the layer and the obtainable stability with the particular type of mixture to be used. In this connection it should be pointed out that the expression "stability," as used in this discussion, is intended to mean the resistance which the layer offers to displacement under traffic rather than any test for the property of stability or resistance to shear as now measured by laboratory methods.

In other words, if a very low stability mixture, as measured by laboratory methods, is laid in a thin layer and tightly stuck to a highly stable layer it becomes a very stable mixture under the meaning intended in this discussion. Hence, the economic thickness of a wearing course is affected by the type of base upon which it is laid and the methods used in its construction. Without further amplification of this thought we might set for the following general table as being the range of economic thicknesses of wearing courses of various types.

It should be understood that this table is intended to be only a general rule rather than being applicable to all cases. For example, there may be instances where it would be advisable and economical to lay a sheet asphalt mixture upon a primed concrete, gravel or macadam base to a thickness of from 1 to 1½ inches without the use of a binder course.

## THICKNESS OF FOUNDATION—CONCRETE BASES

Allowing this brief discussion of wearing course depths to dispose of this part of the subject, let us turn to the matter of the thickness of the foundation with relation to the subgrade. A convincing and conclusive discussion of this part of the subject would be almost a complete solution of all paving problems since the characteristics of the foundation and wearing surface mediums now being used are susceptible of accurate analysis of performance if the performance of the subgrade is known positively.

The earlier studies of the structural performance of pavements were confined almost entirely to the materials and compositions that were used upon the top of the subgrade and the subgrade itself was given no more than casual notice. The pendulum now has swung in the other direction and attention now is being focused upon the subgrade, giving the superimposed pavement only secondary consideration. This probably is much nearer the proper method of approach and would be the correct method if each foundation type is considered as an individual case acting strictly in accordance with conditions as they actually exist in the pavement structure.

The history of subgrade studies with relation to pavement foundations has been well expressed by Professor Charles Terzaghi, in his discussion of Mr. A. C. Rose's paper on "Foundation and Drainage of Highways" as given in the "Transactions of the American Society of Civil Engineers, 1930," as follows: "In the history of every applied science it is possible to distinguish three successive stages. In the first stage, due to limited experience, the ultimate solution of the problems involved seems to be within easy reach and attainable within a few years. In the second, a broader knowledge of the empirical facts is acquired and the unsuspected complexity of the phenomena almost completely destroys one's confidence as to the possibility of discovering anything resembling simple relations as fairly valid laws. In the third stage, a separation is achieved between essential and unessential facts and, instead of universally valid laws of nature, modest rules are established with a small but well known range of validity."

## RELATION OF SUBGRADE TO FOUNDATION DESIGN.

A study of the literature is the speaker's only source of information and this leads to the conclusion that we are now in Professor Terzaghi's second stage of development. It therefore is not the intention to attempt discussion of any conclusions on the relation between foundation thickness and character or condition of subgrades because it is believed that such a discussion is impossible at this stage of the development of the science of subgrades. Instead, an attempt will be made to point out the speaker's opinion of the considerations which will be necessary in order to interpret the relations of subgrade studies to the later design of proper thickness for foundation construction.

To begin, let us make a classification of subgrades on the basis of their physical performance rather than upon their composition and without consideration of the tests to determine their physical performance. Under such a classification we might group the subgrades as follows:

### CLASSIFICATION OF SUBGRADES FOR PURPOSES OF DISCUSSION.

| | |
|---|---|
| Group I. | Uniform high bearing value soils. |
| Group II. | Uniform low bearing value soils. |
| Group III. | Irregular high bearing value soils. |
| Group IV. | Non-uniform subgrades containing both high and low bearing value soils. |

The foregoing method of grouping the subgrade soils is very elementary indeed because it is evident that a certain subgrade may pass from one grouping to another, due to some radical change in moisture content or on account of freezing and thawing. That is, a subgrade may pass from Group I to Group II simply by having the soil pass from a desirable moisture content to a highly saturated condition. Also, a Group I subgrade may pass from Group I to Group III or IV simply by being frozen either into an irregular high-bearing-value soil or, at partial thawing, into a non-uniform subgrade containing both high and low-bearing-value soils. Naturally, if the design of the pavement is ample it should be based upon the poorest condition which the subgrade may be in for any period which may be prolonged over a sufficient time to produce a detrimental effect upon the durability of the construction.

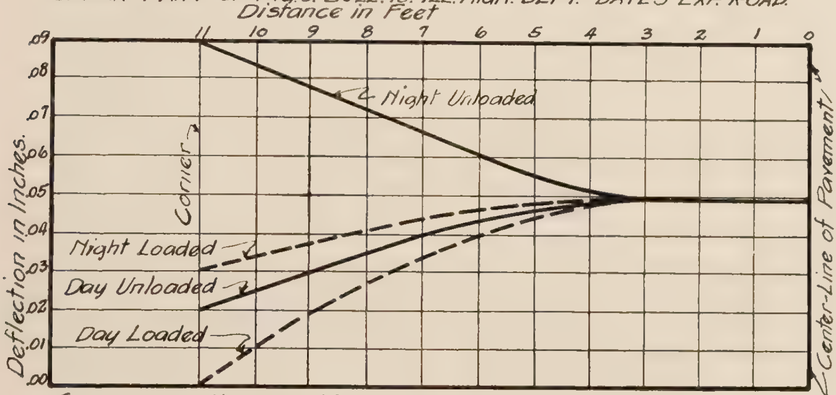
## SUBGRADE STUDY RESULTS SOMETIMES OBSCURE.

In the earlier remarks in this paper the statement was made that the present investigations of subgrades were being made in such a manner that the superimposed pavement is given only secondary consideration. By this statement it is meant that the speaker's opinion is that the interpretation of the results already obtained in subgrade studies are not always given their correct meaning on account of making improper assumptions with regard to how the pavement acts with respect to the subgrade. To simplify this discussion we will confine ourselves first to a discussion of the difference between the action of a concrete pavement and a concrete foundation beneath an asphalt pavement.

It is unfortunate that this comparison is necessary but the investigations now being carried on seem to have as their objective the solution of the subgrade problem for the concrete pavement with the intention that these conclusions be applied in their entirety to the concrete foundation beneath the asphalt pavement. Under a given subgrade condition let us see now what happens when a load comes upon a pavement structure constructed of concrete as a concrete pavement and then the same load on a concrete foundation with an asphalt or brick wearing surface.

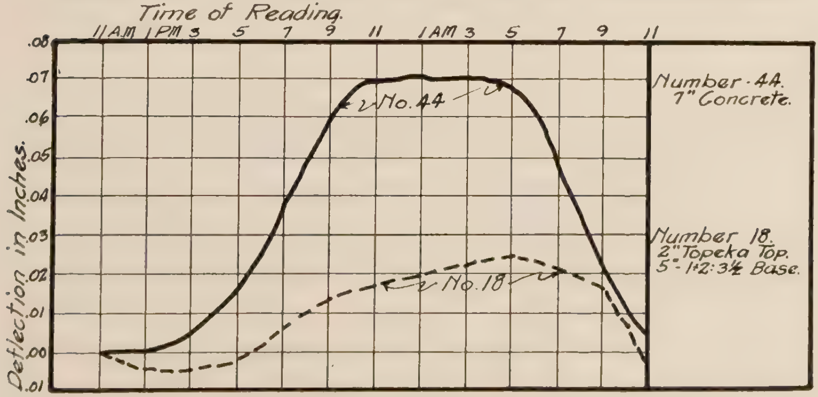
First let us refer to the information on curling of the concrete pavement and concrete foundation as given on pages 11 and 13 of Bulletin No. 18, of the State of Illinois, "Bates Road Test."

UPPER PART OF FIG. 3. BULL. 18. ILL. HIGH. DEPT. BATES EXP. ROAD.



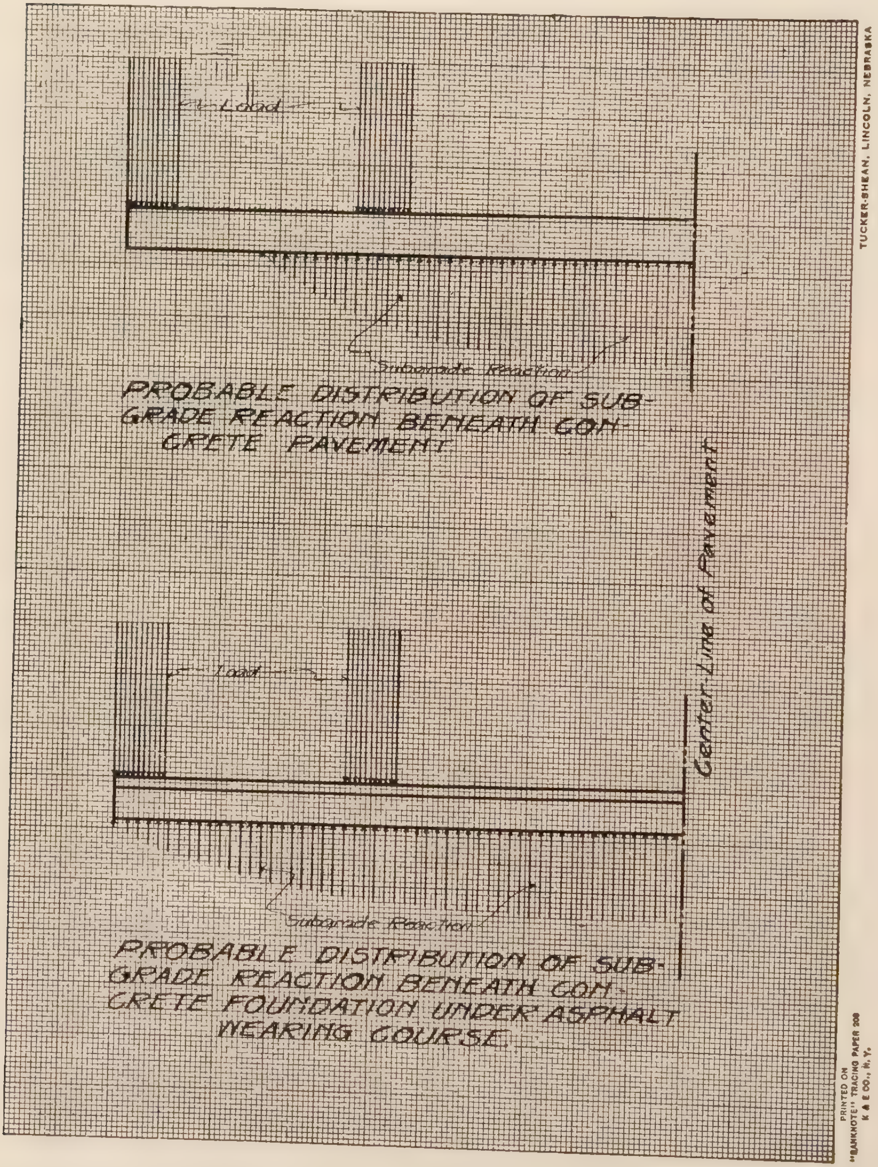
CURLING OF NUMBER 44 - 7 IN. PLAIN. NO DIVIDING PLANE.
CLOSED TRANSVERSE CRACK. 6,000 LB. LOAD.

LOWER PART OF FIG. 5. BULL. 18. ILL. HIGH. DEPT. BATES EXP. ROAD.



CURLING ACTION OF SLABS.

Here it should be pointed out that the concrete pavement curls up to an amount that is three times as great as the concrete foundation having the same width. Now let us see what we should naturally suppose this


Load
Subgrade Reaction
PROBABLE DISTRIBUTION OF SUBGRADE REACTION BENEATH CONCRETE PAVEMENT
Center Line of Pavement
Load
Subgrade Reaction
PROBABLE DISTRIBUTION OF SUBGRADE REACTION BENEATH CONCRETE FOUNDATION UNDER ASPHALT WEARING COURSE.
TUCKER-SHEAN, LINCOLN, NEBRASKA
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will do to the intensity of pressure which may be exerted upon the subgrade beneath these two pavements.

These diagrams are offered simply as an assumption of the probable distribution and relative intensity of the pressures on the subgrades in the two cases, when the slabs are curled up at the edges. The character of the reactions, of course, will be changed when the slabs are curled in the other direction but the same relief is offered the concrete foundation. Unfortunately the speaker is too weak at mathematics to solve these intensities of pressure in the two cases but here are the proper assumptions for the mathematicians to work upon.

The only conclusion which can be arrived at from this point of view is that either the concrete foundation of equivalent slab strength is ample over much weaker subgrades or over a subgrade of given quality a much weaker slab is equally efficient as a pavement when compared with a concrete pavement of a given slab strength.

### Analysis of Stresses in Concrete Roads

Now let us refer to the extremely enlightening analysis of the stresses in concrete roads as made by Professor H. M. Westergaard, and reported in the "Proceedings of the Fifth Annual Meeting of the Highway Research Board." Before we consider the results of Professor Westergaard's calculations it should be pointed out that this mathematical analysis is based upon certain assumptions, given as follows:

"First, the wheel loads are dealt with as static loads."

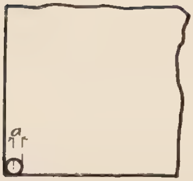
"Secondly, the subgrade is assumed to be uniform, without local soft or hard spots, and to be everywhere in contact with the slab."

The last part of the second assumption is not true (and this is recognized by Professor Westergaard) in the case of a concrete pavement or a concrete foundation beneath an asphalt pavement but comes much nearer the truth in the latter case. Regardless of this assumption, however, the analysis is extremely valuable. Without attempting any further discussion of this analysis let us take some of the results of the calculations of stresses in the concrete due to a load of 10,000 pounds applied at three different points on the slab. The following stresses are

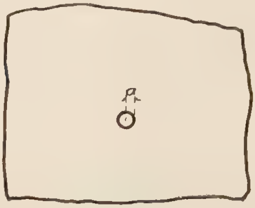
Maximum Stress in Concrete Due to Load of 10,000 Pounds

Modulus of Elasticity of concrete, 3,000,000. Poisson's Ratio, 0.15.

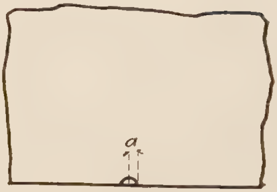
| Thickness of Slab H, In. | Modulus of Subgrade Reaction, K, Lb. per Cu. In. | Stress in Slab, Lb. per Sq. In. | | | | |
|---|---|---|---|---|---|---|
| | | a-0″ | a-2″ | a-4″ | a-6″ | |
| 8 | 50 | 469 | 373 | 325 | 285 | Case I, Figure I. |
| | 100 | 469 | 363 | 309 | 265 | |
| | 200 | 469 | 352 | 291 | 242 | |
| 8 | 50 | 288 | 276 | 250 | 222 | Case II, Figure I. |
| | 100 | 273 | 261 | 235 | 207 | |
| | 200 | 258 | 246 | 220 | 192 | |
| 8 | 50 | 457 | 436 | 388 | 337 | Case III, Figure I. |
| | 100 | 430 | 409 | 361 | 311 | |
| | 200 | 404 | 382 | 334 | 284 | |



Case I.
Figure I.



Case II.
Figure I.



Case III.
Figure I.

based upon an assumed modulus of elasticity of concrete of 3,000,000 and a Poisson's ratio of 0.15.

This table discloses some extremely interesting information. For example, if the subgrades considered above are assumed to be elastic the one having a modulus of subgrade reaction of 50 will bear up a load of 5 pounds per square inch with a penetration of one-tenth of an inch, or a load of 720 pounds per square foot. The subgrade having a modulus of subgrade reaction of 200 will bear up a load of 20 pounds per square inch, or 2,880 pounds per square foot with the same penetration. With this great difference in bearing value the stress in the concrete at the most critical point in Case III is increased only 53 pounds per square inch in changing the subgrade from one having a bearing value of 2,880 pounds per square foot to one having a bearing value of only 720 pounds per square foot. This last subgrade would certainly be classified as having a poor bearing value.

If the subgrade had a bearing value of only 360 pounds per square foot with a penetration of 0.1 inch the difference in the stress in the slab would only be 80 pounds per square inch as compared with one having a bearing value of 2,880 pounds per square foot with the same penetration. In other words, increasing the bearing value of the soil 8 times decreases the stress in the slab only 20 per cent in this case. Remember, however, that these calculations are based upon the assumption that the subgrade is uniform and that it is in contact with the slab at every point. These calculations would seem to indicate that uniform low supporting power of the subgrade cannot be the cause of failure of a concrete pavement or a concrete foundation beneath an asphalt wearing surface if we have any factor of safety.

## Effect of the Spreading of the Load.

The next very interesting thing that can be shown by these figures is the remarkable reduction in stress in the concrete that is brought about by a very small increase in the distribution of a given load. The letter "a" in the figures indicates the radius of the circle upon which the load of 10,000 pounds uniformly is applied. An inspection of the table shows that if the radius of this circle is increased from 2 inches to 6 inches, the stress is reduced by 98 pounds per square inch in Case III. In other words the spreading of this load from a radius of 2 inches to one of 6 inches has a greater effect upon relieving the stress in the concrete than changing the subgrade from one having a bearing value of 360 pounds per square foot to one having a bearing value of 2,880 pounds per square foot. This fact is of considerable interest in connection with the effect of an asphalt wearing surface upon the stresses produced in a concrete foundation.

There is not the least question but that a two-inch asphaltic wearing surface will tend to spread the load which may be applied to its surface over a much greater surface of the concrete foundation beneath it. For a standing load the cone of pressure may be as steep as 45 degrees but for a rapidly moving load it is doubtless true that the cone of pressure is much flatter than this. For purposes of comparison, however, let us assume the angle of 45 degrees and see what the effect is upon the stresses in the concrete foundation. If the load is applied at the surface of the asphalt on a circle having a radius of 4 inches the same load will reach the concrete foundation over a radius of 6 inches. The corresponding reductions in stress in the concrete in Cases I, II and III would be 49, 28 and 50 pounds per square inch, or a reduction of 16.8 per cent, 12.8 per cent and 15 per cent, respectively. In view of the fact that the spreading of the load probably will be many times greater when it is applied suddenly and, since this is the most destructive loading condition for a concrete pavement, that, in part, accounts for the superior performance of concrete beneath an asphalt wearing surface as compared with unsurfaced concrete.

### RELATIVELY WEAK SUBGRADES UNDESIRABLE.

While we are at this point it might be well to digress just a little to discuss the following oft-repeated statement: "Wearing courses do not necessarily increase the resistance of the bases to initial cracking caused by loads. They protect, however, concrete bases against progressive breakage following initial load cracking." It is hard to imagine a situation where an asphalt wearing surface does not protect against cracking before initial cracking occurs but will suddenly furnish this same protection immediately afterwards. The foregoing discussion of the spreading of the external load shows one way, among several, in which an asphalt surface protects its foundation.

Returning again to Professor Westergaard's analysis and to the table of types of subgrades we find that the concrete foundation can be designed economically for subgrades either in Group I or Group II. Unfortunately, however, any subgrade which falls in Group II is readily thrown into Group III or IV either by freezing and thawing or passing from an extremely wet condition to a dry state. Therefore, even though the relatively weak subgrade is not dangerous because of its weakness it usually is very undesirable because of its easy transition to a condition which is very unfavorable to the rigid type of pavement or pavement foundation.

That Group III subgrades are very unfavorable to rigid types of pavement or foundation amply is shown in Professor Westergaard's discussion given in his paper on "Mechanics of Progressive Cracking in Concrete Pavements" in the June, 1929, issue of *Public Roads*. This same point also is demonstrated in Mr. A. T. Goldbeck's paper on "Foundations for Asphalt Pavements" in the June, 1930, issue of *Engineers and Engineering*. In substance these show that irregular high-bearing-value subgrades are not dangerous if the high spots in the subgrade are only one or two feet apart but if they are as great as ten feet apart the result is disastrous to the rigid slab. When the high spots of high supporting value are greater than a distance of ten feet the utilization of such subgrades by designing thicker foundations becomes almost an economic impossibility.

Therefore, it would appear that successful and economical foundations of the rigid type are only possible upon subgrades of Groups I and II and only on subgrades of Group II when they are so uniform in composition that they are not thrown into Group III during cold weather, which condition would be very rare.

## ACTION OF "BLACK BASE" UNDER LOAD

The action of "black base" under load has not been given the careful mathematical study that the rigid type of construction has received. When such a study is made, however, it should be undertaken under different assumptions than that for the rigid type for the reason that this type of foundation always is in contact with the subgrade at every point. Also, it would seem self-evident that under a swiftly moving load this type of foundation will act much more as a unit than the same foundation under a static load.

The fact that "black base" is always in contact with the subgrade is of assistance to this type of construction as is illustrated by the following to be found in the paper by Mr. C. A. Hogentogler on "Influence of Subgrade Support on Pavement Design," in the November, 1929, issue of *The Nation's Traffic*: "Weighting the sand adjacent to the loaded area appreciably increases its support. This also is not true for clays. For instance, a weight of about 100 pounds per square foot placed adjacent to the loaded strip one foot wide may increase the unit support of the sand from 1,000 to about 2,000 pounds per square foot. Under the same conditions, the unit support in the clay may be increased but about 10 per cent, or from 1,000 to 1,100 pounds per square foot." The pressure exerted by the weight of the "black base" and wearing surface itself will amount to from 60 to 80 pounds per square foot and this blanket of pressure should be of some assistance in increasing the bearing value of a sandy subgrade.

The fact that traffic loads on pavements are moving loads is very favorable to the "black base" type of construction since under a quickly applied load there is no question but that the pavement surface is deflected for a considerable distance on every side of the load. This deformation of the pavement structure of necessity increases very materially the area of the subgrade which is deformed and consequently reduces the intensity of pressure a corresponding amount.

By this it is not intended to leave the impression that "black base" should ever be laid over a subgrade which is of low bearing value. It is a very fortunate situation that engineers generally are of the opinion that "black base" should only be laid over subgrades of good quality as this makes the proportional number of successful installations much higher than otherwise would be obtained. However, it is just as questionable whether truly successful work with the rigid pavement or the rigid type of foundation is any more apt to be obtained over the poorer subgrades.

With the "black base" type of construction successful results will be obtained with subgrades of Group I or Group III. It is very doubtful, however, if Group I subgrades need a supporting value as high as 2,000 pounds per square foot as is suggested in the "Committee Report of the American Road Builders Association for 1930."

### BEHAVIOR OF THE MACADAM BASES

Much the same conditions are encountered with the macadam base as the "black base" in so far as its action is concerned; that is, it should be suitable over the same type of subgrades. However, for a given loading it is necessary of course to have a greater depth. In connection with the necessary depth for macadam construction the tests of Mr. A. T. Goldbeck, as reported in "Researches on Structural Design of Highways," from "Transactions of the American Society of Civil Engineers, 1925" have been referred to as showing that eight times the depth of macadam as compared to concrete is necessary to give equal intensity of pressure on the subgrade. It is doubtful if such a conclusion is justifiable from this demonstration because the tests were not made under road-building conditions and the loads were not applied in a manner similar to traffic loads.

This discussion certainly has not clearly met the points given in the title but the information now available makes such a treatment of the subject impossible. It would seem that such a discussion will always remain impossible for the various types of foundations until the study of subgrades is related directly to the actions of the super-imposed pavements. This paper has been devoted to the proposition that the rigid pavement, the rigid foundation and the flexible foundation each have separate and distinct characteristics which must be dealt with in conjunction with the subgrade studies before a rational answer will be obtained. Before this can be done, however, a more comprehensive study first should be made of the real action of "black bases" and macadam bases under traffic loading conditions. If this were done in a thorough manner it is the speaker's opinion that they would come into much more general use.

In conclusion, a prophesy of the ultimate disposition of the subgrade problem will be ventured. From a review of the results obtained in this study it is believed that the economic solution will be not to attempt to vary the design of the foundation to suit the particular subgrade which may be encountered but to make a study of the subgrade for the purpose of determining what remedies should be applied to improve its quality up to a certain degree of perfection. The pavement foundation then will be designed for this type of subgrade and of a thickness which is ample for the type of pavement contemplated and the character of traffic anticipated.

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CHAIRMAN BAKER: Now, we have a very pleasant surprise for all of you. We shall devote about ten minutes to a discussion of "The Political and Social Economics of Highway Improvement," by Prof. Arthur H. Blanchard of Toledo, O.

# The Political and Social Economics of Highway Improvement

**By Arthur H. Blanchard, Toledo, O.**

*President, International Traffic and Transport Association*

I thank you for the courtesy of allowing me to present this subject which is very close to my heart and which, I trust, will be of interest to you. In making public addresses I endeavor to follow as closely as possible three rules laid down by a former Secretary of the Interior: "First, stand up so they can see you. Second, speak out so they can hear you. And third, shut up so they will like you."

Now, as applicable to the subject which you have heard presented I want to quote a statement from Lord Macaulay which is applicable also to this problem. It reads as follows:

> The real use of travel to distant countries and studying the annals of past times is to preserve man from the contraction of mind which those can hardly escape whose whole communion is with one generation and one neighborhood.

With due apologies to Lord Macaulay, allow me to paraphrase this as follows that it may fit the problem before us: "The real use of investigating other fields of activity and of studying the annals of past practices is to preserve men from the contraction of mind which those can hardly escape whose whole communion is with one generation and one specialty."

## Wastage in Handling Highway Funds

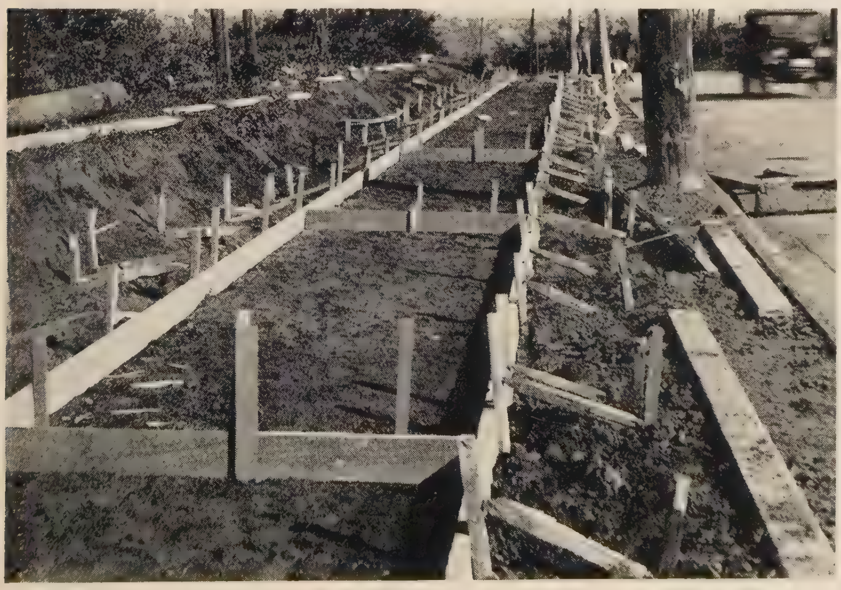
I am not going into an extensive statement in regard to the present practice relative to the expenditure of public funds for highway improvement. Let me ask you two or three questions and you can think them over at such time as you may be in an attitude for the consideration of public benefits. What percentage of the annual highway budget of mililons of dollars goes into roads? Who knows? What percentage is paid for promotion to lay members of county commissions, township boards and council committees? Again I ask, who knows? We in the know are aware that in dollars laymen are handling millions annually. As Mark Twain once so aptly said: "What are we going to do about it?" Well, gentlemen, we don't have to look very far to find the remedy. The insurance companies of this country ten years ago were up against exactly the same problem relative to the refund on insurance premiums and they had the backbone to take the problem in hand and see that proper legislation was passed. All honor to the State of Iowa for leading the procession and now every one of the forty-eight states has on its books legislation that absolutely prevents that practice.

# Construction of Bituminous Surfaced Concrete Sidewalks

**By A. W. Haddow, Edmonton, Alberta, Can.**
*Municipal Engineer, City of Edmonton*

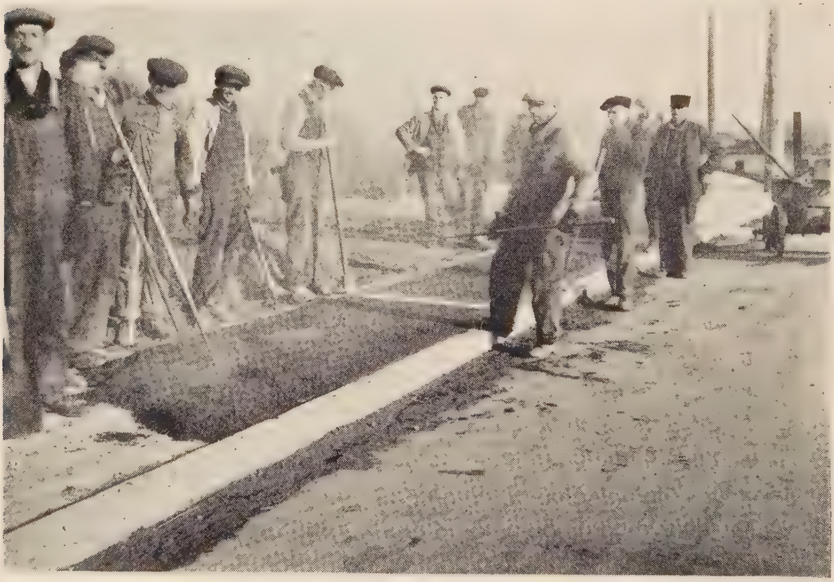
The City of Edmonton has developed a bituminous surfaced concrete walk which seems to meet with general public approval. This walk comprises a four-inch base of 2,500-pound Portland cement concrete, surfaced with one inch of sheet asphalt mixture. The details are shown on the blue print copy of our drawing of June 30, 1930, attached.

The methods of construction are illustrated on the attached photographs which are self explanatory. The grading work is done in the usual way, with teams and hand labor, by a grading gang using wagons and scrapers. The fine grading is done by hand labor by the concrete gang, and wooden forms are set to line and grade along the edge of the walk, with spacing boards at intervals of 25 feet to provide for expansion and contraction. The 2,500-pound concrete then is poured and the side and transverse surface retaining shoulders one inch high are immediately completed. The sheet asphalt surface is mixed at the city paving plant in batches containing 1,000 pounds of paving sand, 115 pounds of asphaltic cement (D grade; penetration 58-63) and 41 pounds of paving dust filler. This mixture is hauled to the job in trucks, spread in the usual way with hot rakes and consolidated with a 1,700-pound water ballasted



Laying Asphalt Surfaced Concrete Sidewalks in Edmonton, Alta., Canada. Forms Set, Ready for the Concrete Base. Photographed November 5, 1930.

roller, 30 inches in diameter and 30 inches wide, and Portland cement concrete or paving plant dust is dusted over the freshly consolidated surfacing. The street gang, comprising a foreman and twenty men, complete an average of 1,500 to 1,800 lineal feet of surfacing per eight-hour day. The total cost of one-inch surfacing per square yard is 66 cents. Very often the surfacing is not laid for several weeks after the base but this causes no inconvenience to pedestrians as they use the base.



Constructing Asphalt Surfaced Concrete Sidewalks in Edmonton, Alta., Canada. Laying One-Inch Sheet Asphalt Surface Mixture. Note Hand Roller Used for Consolidation. Photographed November 5, 1930.

### Construction Costs of the Sidewalks

The total cost of construction is 30 cents per square foot, which is practically the same—if anything, slightly less—than the comparative cost of Portland cement concrete walk of the same standard. The above cost includes all charges for labor, material and auxiliary work, such as reconstruction or adjustment of utilities, including hydrants, poles, private approaches, etc., and also a departmental charge for overhead of 5 per cent. This construction is carried on as a local improvement and is assessed against the abutting property. For purposes of assessment, the cost of the necessary street and lane crossings are included. These crossings are constructed altogether of Portland cement concrete slab, 6 inches thick at lanes and 7 inches at streets. This construction, together with the cost of construction interest, debenture discount and flotation charges, then is assessed against the abutting property. We pool the whole season's program, including the street and lane crossings involved, and set a unit annual rate per property foot (or per lineal foot of walk) of 16 cents, continuing for a period of twenty years. On this basis we have constructed 85.24 miles of this class of walk.

Some current rates for labor and material effecting this class of construction, are as follows:

LABOR

| | |
|---|---|
| Common hand labor | 50c per hour |
| Skilled hand labor | 52c per hour |
| Team and teamster | 95c per hour |
| Cement finisher | 80c per hour |
| Asphalt rakers | 57c per hour |
| Concrete foreman | 1.00 per hour |
| Asphalt foreman | $144.00 per month |

MATERIAL

Asphaltic cement, $29.00 per ton in tank cars, F. O. B. paving plant.

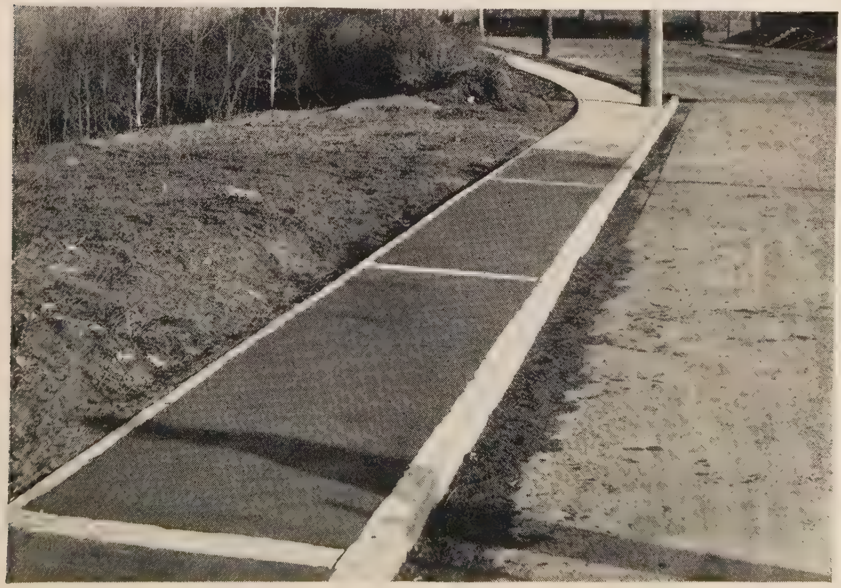
Paving sand, $1.75 per cubic yard, F. O. B. paving plant.

Concrete sand, $1.90 per cubic yard, F. O. B. paving plant.

Coarse aggregate, ¾ inch crushed rock, $3.40 to $3.75 per cubic yard, F. O. B. job.

Portland cement, 95c per sack (87½ lbs.)

The above type of construction has been developed through the stress of circumstances. Prior to the war, there was a great deal of speculation in city real estate, with the consequent abnormal expansion of city limits to 42½ square miles. This expansion necessarily involved the extension



Asphalt Surfaced Concrete Sidewalks in Edmonton, Alta., Canada. The Completed Structure. The Light-Colored Surface in the Background has been Dusted with Paving-Plant Dust. The Pavement in the Foreground has not yet been Dusted. Photographed November 5, 1930.

of public utilities to serve a very scattered population and as a result many miles of plank walk were constructed. During the war and post-war periods, there was a drastic retrenchment in all public expenditures, with the result that our plank walks fell into a state of serious disrepair, causing payment by the city of many claims for personal injuries received in tripping and falling over loose and decayed plank surfacing. Many of the worst walks were dismantled and cinders were substituted, first with two-inch wooden edging and later with Portland cement concrete stringers. These cinders, however, made a very unsatisfactory surface, both for pedestrians and also for the adjoining household floors and carpets. We then found it necessary to surface some of these walks, using first the penetration method and later the central plant mix. This surfacing immediately proved very popular with the public on account of its resiliency, the general comment being, "It is easy to walk on." When we were able to get back to the old construction, with the Portland cement concrete we retained the bituminous surfacing as a feature of our permanent walks.

### ADVANTAGES OF DUAL CONSTRUCTION.

The general advantages of this construction, as developed by our experience, are:

(1.) Resilient surface for pedestrian traffic. As stated above, it meets with general approval in this regard and, also we have found, it causes very much less abrasion to footwear than a Portland cement concrete surface.

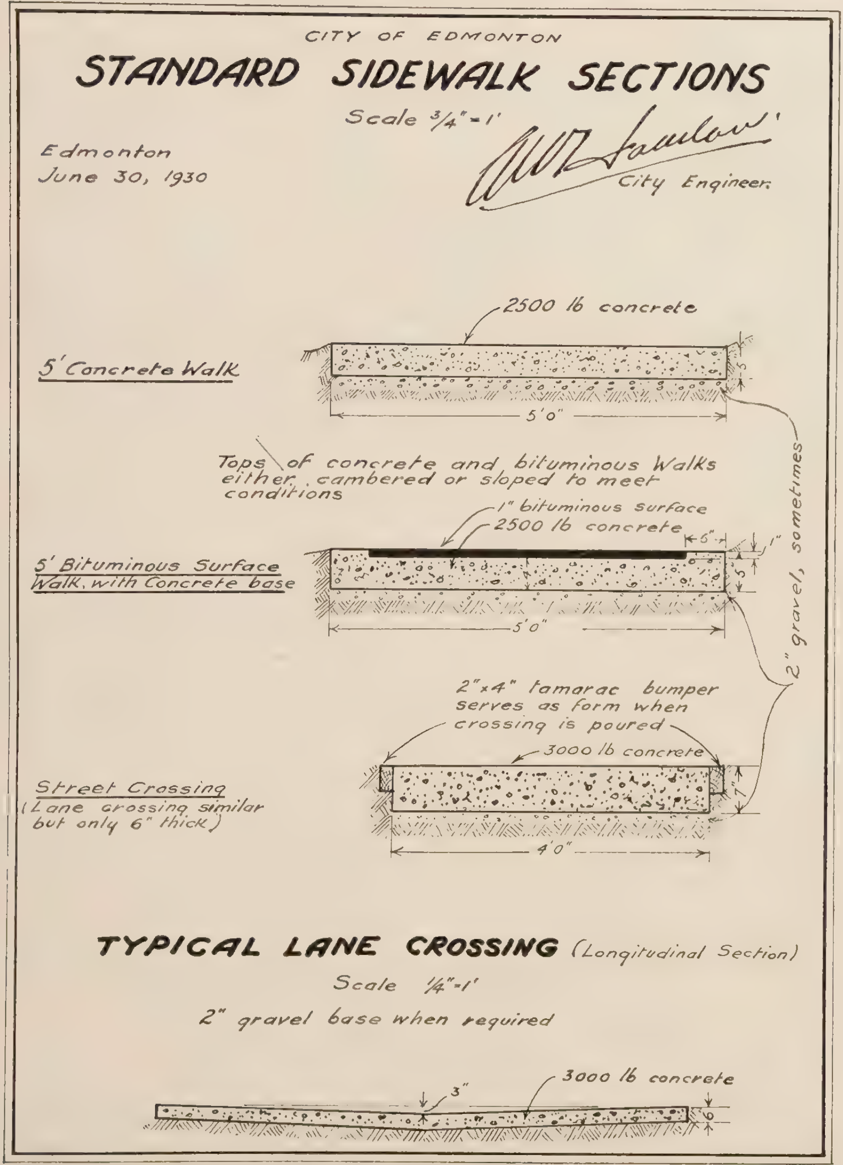
(2.) Finishing work can be carried on much later in the season. We usually get light frosts after the 15th of September. Consequently finishing Portland cement concrete surface involves protection after that date and possible injury from frost.

(3.) Freedom from sun glare. The dark surface is restful to the eyes. Under our conditions we have a very clear air and brilliant sunshine, especially during the summer months, when it is daylight from 3:30 in the morning until 11 o'clock at night.

A short recital of our general conditions effecting this construction may be of interest. The City of Edmonton is the capital of Alberta, and is situated 300 miles north of the international boundary line, adjoining the State of Montana. It is surrounded by a very fine agricultural and dairy district. The district is also exceptionally rich in such natural resources as coal, natural gas and oil. The soil structure generally is one to three feet of rich, black loam overlying brown clay. Rock is several hundred feet below the surface.

The general elevation of the city is 2,200 feet above sea level and the distance from the Pacific Coast in an airline is 600 miles and with the Rocky Mountains, whose general peak elevation is approximately 10,000 feet above sea level, intervening. The average annual precipitation is 18 inches, made up of 14 inches of rain and 4 inches equivalent of snow. We are subject to wide variations in temperature, ranging from 90 degrees F. in summer to 50 degrees below zero occasionally in winter. In this connection, a rather remarkable feature is the "Chinook Wind," more generally known as the "Foehn Wind" in Europe. This wind will raise the temperature from 50 degrees below zero to 50 degrees above in from one to two hours. It is essentially a moisture laden wind blowing from the coast over the mountain barrier. As it strikes the land mass and western slopes of the mountains, it is forced upward and cooled about 1.6 degrees F. every 300 feet. As a result it soon reaches its dew point and precipitates moisture. The cooling on account of expansion is reduced to one half on account of the latent heat of condensation being

FIGURE I


CITY OF EDMONTON
STANDARD SIDEWALK SECTIONS
Scale 3/4"=1'
Edmonton
June 30, 1930
City Engineer.
2500 lb concrete
5' Concrete Walk
5'0"
5"
Tops of concrete and bituminous Walks either cambered or sloped to meet conditions
1" bituminous surface
2500 lb concrete
5"
1"
5' Bituminous Surface Walk, with Concrete base
5'0"
2" gravel, sometimes
2"x4" tamarac bumper serves as form when crossing is poured
3000 lb concrete
7"
Street Crossing
(Lane crossing similar but only 6" thick)
4'0"
TYPICAL LANE CROSSING (Longitudinal Section)
Scale 1/4"=1'
2" gravel base when required
3000 lb concrete
3"
6"

Cross-Sections of Unsurfaced Concrete and Asphalt Surfaced Concrete Sidewalks Laid in Edmonton, Alta., Canada, by the Municipal Forces. Also Cross-Section of Street Crossing.

absorbed by the air. The wind crosses the top of the mountain barrier as a comparatively warm and very dry air and descends about 8,000 feet to the eastern foothills and plains and warms up by compression at the same rate of 1.6 degrees F. per 300 feet. It is remarkably dry and will melt as much snow in one day as an ordinary spring thaw will do in two weeks.

From the above conditions, it may be understood that our construction is subject to considerable stress, both on account of change in temperature and on account of the volumetric changes in our clay soil. We have found that an asphaltic surface seems to meet best these conditions of construction which I have described.

## THIRD SESSION

### HOTEL PEABODY, 9:30 A.M., WEDNESDAY, DECEMBER 3, 1930

### M. A. LYON, CHIEF ENGINEER, PROVINCE OF MANITOBA, CANADA, PRESIDING

CHAIRMAN LYON: Gentlemen, I want to take this occasion to thank The Asphalt Institute for inviting the Canadians to take part in these discussions. We certainly appreciate it very much and we also appreciate the honor that you have conferred upon Canada and Manitoba in particular, by asking me to preside this morning. I also would like very much to thank the different state highway departments which have been so kind to us in giving us information and helping us in any way they could. Our problems up there are similar to those in many of your states, particularly the northwestern states, and when we turn to them for information they are always glad to give it. They are always very courteous. I also wish to thank the United States Bureau of Public Roads, the officials of which have always been very courteous and have done anything we asked of them.

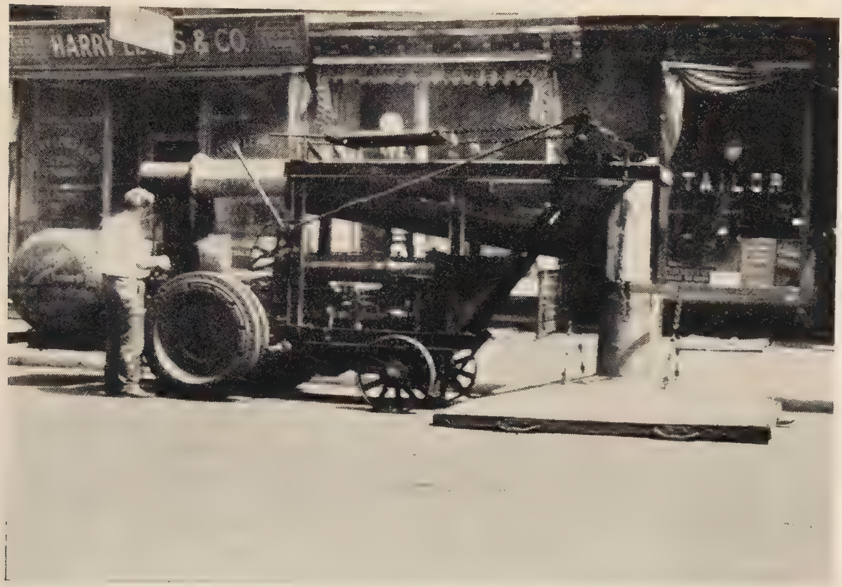
The session opens this morning with a paper by Mr. Frank L. Raschig, first assistant director of the Ohio State Department of Highways. It is a "Survey Report of the Committee on Resurfacing Roads and Streets." Gentlemen, Mr. Raschig.

# Report of the Committee on Resurfacing Roads and Streets

### Frank L. Raschig, Columbus, O.,
*Chairman*

This survey of resurfacing roads and streets has been very interesting to me. We are very much pleased with the great number of replies we have received from all over the country because they have given us a very excellent cross-section of what is going on all over the country in this respect.

There are, in the United States of America, something over 375,000 miles of gravel roads and 65,000 miles of macadam roads on the combined state and county systems. Figuring but $3,000 a mile for the material in the gravel road surface and $7,000 for that in the macadam surface, there has been expended $1,125,000,000 for the gravel and $378,000,000 for the stone, respectively, a total of around $1,500,000,000. That these are conservative figures will be readily appreciated by any engineer engaged in highway construction. In addition to these enormous mileages there are 109,000 miles of brick, concrete and asphalt which represent an additional investment of $3,500,000,000 and which are gradually wearing away under the pounding of modern traffic. The stability obtained under this traffic, however, is of very definite value and worth many millions of dollars. The question confronting the engineer and public official today is, "What shall we do with this enormous investment, throw it away entirely and endeavor to replace it with something new or shall it be the conservation of this enormous sum invested, by utilizing such surfaces as foundations for a new wearing course?"



TYPE OF SURFACE HEATER USED FOR RESURFACING WORK IN NEW YORK.

## NATURE OF INQUIRIES MADE BY COMMITTEE.

Study of a question of such magnitude requires thorough study and a committee, selected from different parts of the United States, has been obtaining information during the year as to present resurfacing practice and method. Approximately one thousand questionnaires were prepared and sent out to state, county and city engineers. The questionnaire contained the following queries:

(1) Has your department salvaged any appreciable mileage of streets or highways by resurfacing with asphalt? If so, give such information as you have available as to original

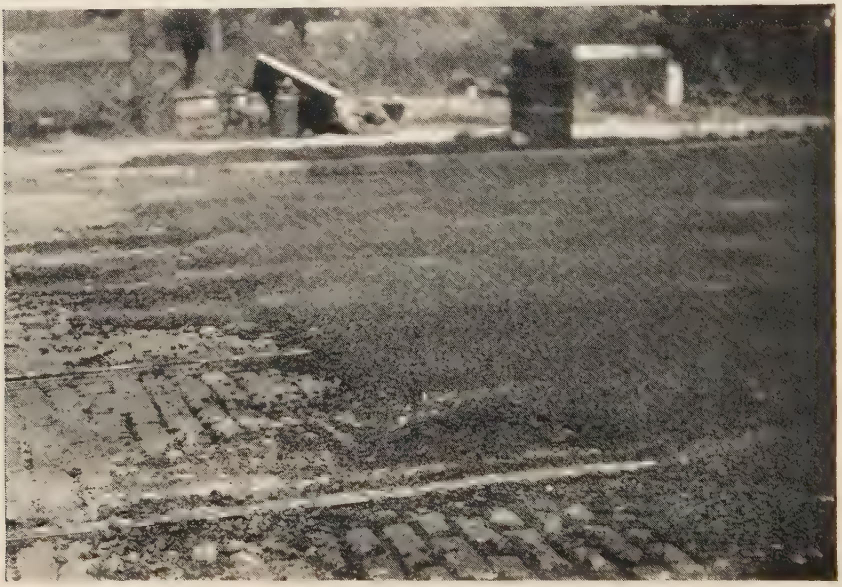
surface and the type of asphaltic surface applied thereto; also size of project, costs, service, etc.

(2) What types and methods in your judgment have given the greatest satisfaction in your resurfacing work?

(3) Have you developed any standard practice in resurfacing? If so, give details.

(4) To what extent does your 1930 program include resurfacing projects?

Replies were received from 30 state highway departments, 162 county departments and 122 cities,—a total of 314. When it is remembered that there are but 48 state departments and many of them are just beginning a construction program and that the vast majority of counties are also in the same category, it will be seen that a surprisingly high percentage of returns were made. From the questionnaires received, a number of follow-up inquiries were made and reports obtained on the yardage of resurfacing which would be representative of the conditions in all parts of the country and which would show fully the methods employed, range of cost and degree of service rendered.



Pawling Avenue, Troy, N. Y. Brick Pavement Containing Double Car Tracks Being Resurfaced with Asphalt without Removing the Rails. Photograph Shows Binder Course as Laid Over the Rails. Minimum Depth of One Inch Desired.

The problem of surface treatment and stage construction is intimately connected with that of resurfacing and, in view of the two other reports covering these subjects, the report of this committee is confined to the resurfacing phase only. Reports on surface treatment covered some hundred million square yards in the particular states, counties and cities reporting. This item of yardage, however, is omitted from the following table.

TABLE I.

*A typical resurfacing record by types on a 4000-mile mileage, taken from questionnaires.*

| | | |
|---|---|---|
| 4000 miles | Original surface<br>Asphalt pavement<br>(6,500,000 sq. yds.) | Asphaltic conc.<br>3,000,000 |
| | | Sheet asphalt<br>3,500,000 |
| | Original surface<br>Old concrete<br>(11,560,000 sq. yds.) | Pen. mac.<br>60,000 |
| | | Asphaltic conc.<br>10,500,000 |
| | | Sheet asphalt<br>1,000,000 |
| | Original surface<br>Brick, block, cobble<br>(8,050,000 sq. yds.) | Pen. mac.<br>50,000 |
| | | Asphaltic conc.<br>3,000,000 |
| | | Sheet asphalt<br>5,000,000 |
| | Original surface<br>Gravel, waterbound macadam<br>(19,000,000 sq. yds.) | Pen. mac.<br>9,000,000 |
| | | Asphaltic conc.<br>8,500,000 |
| | | Sheet asphalt<br>1,500,000 |

This makes a total square-yardage of resurfacing of approximately forty-five millions, or, reduced to twenty-foot-width pavements, is equivalent to about four thousand miles of highway. This mileage is representative of conditions throughout the country and the conclusions drawn may be made generally applicable.

## Analysis of the Replies Received.

In general, the problems of large counties are similar in part to those of the suburban sections adjacent to the cities and similar to the state problems in the more outlying areas. Practice therefore, for state, county and city can be divided into two general groups,—urban and rural. For the rural areas, there are three general classes of resurfacing: (1) On gravel foundation. (2) On waterbound macadam. (3) On old brick, old concrete and old penetration macadam.

The practice in cities divides itself into two groups:

I. New surfaces on old wearing courses
  (1) On gravel
  (2) On waterbound macadam
  (3) On old brick, old concrete and old penetration macadam.
II. Replacement of wear on asphalt surfaces
  (a) Surface heater method of partial replacement
  (b) Cut-out method with complete resurfacing.

The returns indicate that resurfacing is just beginning on a very substantial mileage of county roads, the main efforts for the past ten years having been to place some kind of surfacing on the principal highways. In many counties the present problem now is to improve the character of the surface to take the increased traffic and to utilize all previous work. In many states officials are confronted with exactly the same problem. The practice, which is typical of the several types, is herewith presented and selection has been made of those states, counties and cities where a very large yardage of a particular type has been employed and brought to a high state of efficiency.

### METHODS EMPLOYED WITH GRAVEL AND MACADAM.

Using gravel foundations, there has been developed four distinct methods of resurfacing: (1) Surface treatment. (2) Retread, or mixed-in-

RESURFACING EXPERIMENTAL SECTION OF THE LINCOLN HIGHWAY, WEST OF SOUTH BEND, IND., WITH SHEET ASPHALT AND ASPHALTIC CONCRETE. OLD CONCRETE ROAD SEVEN INCHES THICK AND OF ONE-TWO-FOUR MIX, LAID IN 1916. RESURFACED ON TEST SECTIONS IN AUGUST, 1925.

place wearing course. (3) Penetration macadam. (4) Asphaltic concrete or sheet asphalt. The practice of surface treatment is covered elsewhere in the program and will not be discussed in this report.

The "mixed-in-place" method is employed largely in Indiana, Michigan, Virginia and West Virginia, as well as in many other states. The practice is to smooth up the original gravel surface by thorough dragging and blading during the spring months of the year. The greatest pains are taken to repair all depressions and weak areas with new material and to bring the surface to a true line and grade. On this prepared base is then placed crushed stone or gravel to a depth of from 1½ inch to 2½ inches loose. Asphaltic material then is applied and the aggregate is mixed and manipulated until a uniform texture is obtained, after which it is then smoothed out and rolled. The important points to be considered are careful and thorough preparation of the gravel surface to a smooth contour and a thorough manipulation of the "mixed-in-place" course, so that a high degree of uniformity is obtained. From fifteen to twenty complete turns of the surface material are needed. The cost of this type of surfacing varies from 35 cents to 60 cents a square yard, according to the availability of materials.

The "mixed-in-place" surface is for medium traffic, although there are instances where it has carried successfully more than two thousand vehicles per day. In general, however, it would be economical for a traffic range of from 500 to 1,200 vehicles daily. In view of the fact that a very large percentage of all rural highways carry less than this figure, it can be seen that this type is adaptable to a very large mileage of gravel roads. For traffic of heavier densities the asphaltic concrete surfacing has been employed successfully on gravel base, notably in Michigan. This method of resurfacing is employed on high class gravel roads where the traffic has become too heavy for ordinary maintenance and an asphalt surface is more economical. Heavy maintenance is carried on over the gravel surface for at least six months to a year prior to surfacing. Good drainage is provided and at least six inches of well compacted gravel should be had. A templet is used to check the cross-section and the surface then is primed at the rate of about ¼ gallon per square yard. Traffic continues to use the road and all weak and ravelled places are thoroughly patched. The side forms then are laid carefully and checked, as upon rigid side forms largely depends the smoothness of the finished surface. The binder course then is placed over the gravel for the purpose of obtaining thorough consolidation and evening up any irregularities and covered at the rate of about one ton for seventeen square yards of surface. This binder is thoroughly rolled and compacted, after which an asphaltic concrete is placed to have a compacted thickness of from 2 to 2½ inches. The important things to remember in the construction of this type are:

(1) Check the gravel base to insure at least 6 to 8 inches compacted depth.
(2) Prime the surface and find any unstable areas.
(3) Smooth up the base course with a thin binder course and thoroughly roll.
(4) Place side form with the utmost care and carefully check smoothness of finished surface.

The methods of resurfacing waterbound macadam are very similar to those employed for gravel except that less work is required to prepare the waterbound macadam to receive a new wearing course. Weak and unstable places show up very quickly in macadam and can be patched readily and the whole surface brought to a true cross-section. Resurfacing practice throughout the country employs surface treatment, penetration macadam and asphaltic concrete. In state work, penetration macadam is used in large volume with asphaltic concrete second. The same applies to county practice. In city work, asphaltic concrete and sheet asphalt predominate.

Stone Filled Asphalt Resurfacing on Old Gravel. The Sturgis Road in Michigan. Photographed After it had Passed through Four Winter Seasons.

### Resurfacing Old Brick, Cobble and Concrete.

These pavements are found on a large mileage, especially in the thickly populated areas of the country. Many of the old brick roads were laid on sand and gravel foundation and under light traffic were quite satisfactory. As the years went by and heavy concentration of loading occurred, many of these pavements became distorted and badly worn. They have, however, become thoroughly stabilized and have a foundation value which can be salvaged very economically by placing asphaltic wearing courses. Returns from a number of city engineers set forth that they preferred old pavements for this purpose as practically all settlement had taken place and the new surfacing did not crack and check as so frequently happened with a new concrete base.

Resurfacing of these types fall into two different groups: (1) Sheet asphalt or asphaltic concrete. (2) Surface treatment of thin macadam. The first method predominates although very excellent results have been obtained in some states and cities with the thin surface treatment. The best practice is as follows: The old surface is cleaned thoroughly; depressions and irregularities are filled with binder until an even and true cross-section is obtained. A binder course of at least one inch in depth then is placed over the entire surface, rolled thoroughly and checked carefully so as not to vary over ¼ inch in ten feet. This step is important because on the care exercised in placing the patching and binder course depends the quality of the finished surface. The wearing course then is placed, with a minimum of 1½ inches compacted thickness.

Harriman Avenue, Jamaica, L. I., New York. Asphaltic Concrete Resurfacing on Old Macadam. Laid in 1930.

Reports selected covering some eight million square yards over old brick and cobble stones indicate thorough satisfaction with this method of resurfacing at costs varying from $1.20 to $2.00 per square yard, depending on the degree of roughness and irregularity of the old pavement. One city engineer commented quite completely on the economics of resurfacing old brick in accordance with the amount of patching required. For his city he estimated the use of 50 pounds of binder per square yard for patching and 100 pounds per square yard for the binder course itself.

Old concrete roads have been resurfaced in a very large mileage. The practice has been carried on in all of the older states and cities and is beginning in some of the newer ones. Reports indicate that in many cases concrete roads from six to ten years old can be resurfaced to advantage. The best practice is:

(1) Careful cleaning of the surface.
(2) Careful pouring of the cracks and repair of old broken and shattered areas.

(3) Placing a binder course of minimum one-inch thickness and preferably 1½ inch thickness, followed by a surface course of sheet asphalt or asphaltic concrete 1½ inches thick.

Costs on this work vary from $1.20 to $2.00 per square yard, depending on the condition of the old surface. In many cases widening is carried on at the same time as the resurfacing work but this phase is contained in a separate paper and will not be discussed here. Several small cities report failure with resurfacing brick and concrete surfaces. Invariably this occurred because of elimination of the binder course and an attempt to lay a thin asphaltic wearing course without providing for proper adhesion to the base.

However, a number of cities, notably one in particular, Rochester, N. Y., have had complete success in resurfacing old concrete and brick with a thin wearing course, eliminating the binder course. However, the greatest pains are taken thoroughly to clean the surface from all oil, grease and dirt and to apply a light coat of asphalt prior to resurfacing to insure a complete bond. As a general procedure the use of a binder course is advisable.

The use of surface heaters generally has been successful, many cities reporting the application of the asphaltic wearing course without binder where the surface has been heated previously, so as to remove all dirt and grease. After thorough heating the surface is sprayed with a light application of asphalt which provides the necessary adhesion for the wearing course.

## Conclusions and Recommendations.

### *Policy.*

(1) The practice of resurfacing old pavements and thus salvaging all previous investment, is eminently sound and results obtained with a wide variety of materials as foundations have been very successful.

(2) While the yardage of pavements so resurfaced has been large, there is need for greater employment of this practice, as in many instances old pavements have been destroyed and replaced by an entirely new structure at unnecessary costs.

(3) Returns show that resurfacing can be done frequently for less than one-half the cost of a new pavement and that the road or street can be reconstructed under traffic, or one-half width at a time, with a minimum inconvenience to traffic.

(4) Further study of the subject is recommended with a view to further reduction in costs and in speed of operations.

### *Engineering.*

(1) There is need for more forward planning of road and street improvements, so as to afford at least six months' time in which to make all needed service cuts, and drainage installations and thus take care of settlement.

(2) In reshaping old gravel or macadam surfaces to obtain a flat crown, or to improve profile, scarify the surface lightly and do not disturb subgrade.

(3) Gravel and waterbound macadam surfaces should be checked carefully during the spring months to discover all weak and unstable areas. Carefully record these areas, station by station, or drive stakes to mark

the limits of the breaks. Do not trust to memory, since by next summer when the resurfacing actually is done, it will be impossible to tell where extra work is needed. Careful checking of this character insures uniform results with a minimum of expense and lower maintenance in the future.

(4) When in doubt as to the bearing qualities of gravel or macadam and when funds are limited, resurfacing either should be a surface treatment or a mixed-in-place surfacing, thus permitting easy reconstruction should additional thickness be required in the future.

(5) The use of asphalt emulsions is increasing.

(6) The use of "mixed-in-place" asphaltic macadam rapidly is growing in favor for rural highways of light to medium traffic.

(7) In resurfacing old brick, block or concrete pavements carefully remove all broken or shattered areas and replace with sound material after remedying all faulty drainage. Carefully patch all depressions and irregularities with binder mix, to uniform cross-section and profile. Place at least one inch of binder over the whole surface and check carefully with a ten-foot straight-edge, prior to placing the top course.

Old Portland Cement Pavement Resurfaced with Sheet Asphalt and Asphaltic Concrete on Lincoln Highway West of South Bend, Indiana.

(8) The binder course is omitted only when a surface heater is used to burn off all oil, grease and dirt, after which a light film of material is sprayed on, prior to placing the surface course. Good results are obtained by this method.

(9) One and one-half inch sheet asphalt top course predominates in cities.

(10) Two-inch and three-inch asphaltic concrete predominates on rural roads.

(11) Greater precision of method is required, including steel side forms, and machine methods of spreading, screening and finishing. In California, on more than 500 miles of resurfaced concrete and macadam, machine methods have reduced the cost and improved the surface to a remarkable degree.

(12) Future pavement design should be such as to provide resurfacing as needed with the complete salvage of the old surface, or minimum reconstruction.

(13) Old surfaces thoroughly stabilized under years of traffic make better foundations than new concrete due to absence of cracking.

# Experimental Bituminous Resurfacing on Old Concrete Pavement

**By Col. Harry D. Williar, Jr., Baltimore, Md.**

*Chief Engineer, Maryland State Roads Commission*

The State of Maryland was among the first in the United States to undertake the construction of concrete roads. The result today is that there are some highways of this type on the system which were built fifteen or eighteen years ago under specifications adequate at the time but long since obsolete. While the value of such roads as a wearing surface is considerably reduced, they are entirely adequate as a base on which to place the proper type of surfacing. In order to determine their relative merits the commission decided to construct test sections with a number of the various types of resurfacing material before permitting their use on state road contracts.

In April, 1930, the old Annapolis road between Sweetzer's Bridge and Glen Burnie, a distance of approximately four and one-half miles, was selected to be resurfaced as an experimental section. Originally this road was built in 1915 and 1917, of concrete, 16 feet wide and 5 inches in depth at the edges and 7 inches in depth at the center. Fourteen different experimental types of resurfacing were selected and laid on this road, each section being approximately 1,700 feet in length. In order to obtain some additional width of the roadway, a concrete shoulder 2 feet wide and 8 inches in depth was constructed along each edge of the existing pavement and raised from 1½ inches to 3 inches, so as to provide a header for the several varying depths of resurfacing materials. On the section resurfaced with concrete a widening of similar width and depth was included as a part of the resurfacing work and was poured at the same time as the resurfacing itself.

## Types of Resurfacing Selected.

This shoulder work was started on May 8, 1930, and the first side was completed May 22. It was necessary to delay starting the shoulder of the opposite side until the fourteen-day curing period had elapsed, since traffic was maintained during this part of the construction. It was necessary to close the roadway during the construction and curing of the concrete section. On the bituminous section traffic was detoured during the actual laying of the material but was permitted to use the road from 6 P. M. until 7 A. M. This work was started on June 6 and completed July 9, 1930. Weather conditions uniformly were favorable during the entire operation. The types laid were as follows:

(1) Concrete Resurfacing (4″ in depth)
As recommended by Portland Cement Association.
(2) Asphalt Penetration (3″ in depth)
As recommended by the Barber Asphalt Co.
(3) Bitumuls (2″ in depth)
As recommended by American Bitumuls Co.
(4) Amiesite (2″ in depth)
As recommended by The Interstate Amiesite Co.
(5) Colprovia (2″ in depth)
As recommended by Colprovia Roads, Inc.
(6) Bituminous Concrete (2″ in depth)
State Roads Commission Specifications.
(7) Macasphalt (½″ in depth)
As recommended by Macasphalt Corporation of America.
(8) Asbestophalt (1½″ in depth)
As recommended by Warren Brothers Road Company.
(9) Westphalt (1½″ in depth)
As recommended by Westphalt Company of Pennsylvania.
(10) Bituroc (1½″ in depth)
As recommended by Ohio Valley Rock Asphalt Co.
(11) Kyrock (1½″ in depth)
As recommended by Kentucky Rock Asphalt Co.
(12) Slagmac (2″ in depth)
As recommended by The Standard Slag Co.
(13) Tarmac (2″ in depth)
As recommended by The American Tar Products Co.
(14) Tarvialithic (2″ in depth)
As recommended by The Barrett Co.

All of these types were laid under the specifications and direct supervision of the companies recommending them. Inspectors from the State Roads Commission and from the United States Bureau of Public Roads were on the work at all times acting as observers. The details of the construction of the various types and also a complete crack survey of the original pavement follow.

Analyses were made of samples taken from the bituminous sections. In some cases these samples apparently were not typical of the average run of material and in such cases the values indicated are taken from the manufacturer's specifications instead of from the samples.

### SECTION NO. 1

*Type*: Portland cement concrete.

*Thickness of Surface*: Four inches.

*Construction*: This section was designed to be four inches in thickness over the existing sixteen-foot road, with shoulders two feet wide by nine inches thick, cast monolithically with the surfacing. However, on account of the irregularities in the contour of the existing road, the thickness obtained varied considerably from that contemplated. On account of these irregularities the thickness of the surfacing was held to a minimum of three inches at the crown of the old road in order that the thickness of the new pavement at the edge of the old road would not greatly exceed four inches. In spite of these precautions, measurements taken to determine the thickness of the new slab showed that in some places it was as much as seven inches thick at the edge of the old road. The new surfacing was given a crown of two and one-half inches.

The new surfacing has a dummy longitudinal joint, one and one-half inches deep, filled with paper joint material one-sixteenth of an inch thick and one-inch transverse expansion joints at intervals of 105 feet, with intermediate transverse dummy contraction joints at thirty-five foot intervals. Reinforcing steel was not broken at these dummy joints so that we had an effective slab length of 105 feet. Wire mesh reinforcement was placed two inches under the surface of the new pavement. This mesh reinforcement was made up of one-quarter inch wires spaced six inches apart longitudinally and twelve inches transversely.

The aggregate used were washed sand and gravel from the Arundel Patapsco plant. They were graded as follows:

*Sand*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Passing | 200 mesh sieve | | | | | | 0.5% |
| " | 100 and retained on 200 mesh sieve | | | | | | 1.5% |
| " | 80 | " | " | " 100 | " | " | 1.5% |
| " | 50 | " | " | " 80 | " | " | 7.0% |
| " | 40 | " | " | " 50 | " | " | 11.0% |
| " | 30 | " | " | " 40 | " | " | 16.0% |
| " | 20 | " | " | " 30 | " | " | 12.0% |
| " | 10 | " | " | " 20 | " | " | 25.0% |
| " | ¼″ | " | " | " 10 | " | " | 25.5% |
| | | | " | " ¼″ | " | " | 0.0% |

Specific Gravity 2.68

*Gravel*

| | | | |
|---|---|---|---|
| 2.0% | passing | ⅜″ | Sieve |
| 5.0% | " | ½″ | " |
| 20.0% | " | ¾″ | " |
| 40.0% | " | 1″ | " |
| 20.0% | " | 1¼″ | " |
| 10.0% | " | 1½″ | " |
| 3.0% | " | 2″ | " |

Specific Gravity 2.66

The concrete mix that was used was designed by the State Roads Commission. It was that of a one-bag batch containing 200 pounds of sand and 360 pounds of gravel, requiring 1.5 barrels of cement per cubic yard of compacted concrete. Five-bag batches were used and each batch remained in the mixing drum for one minute. The amount of water used in the mix was controlled by slump tests taken at intervals, the maximum slump being one inch. The concrete was finished by means of a Heltzel finishing machine. The surface of the pavement was covered with wet burlap soon after finishing and was sprinkled with water for twenty-four hours, after which the surface was treated with silicate of soda solution applied as a spray. A mixture of three parts silicate of soda and one part water was used on the surface of the pavement and undiluted silicate was broomed on the edges. The section was closed to traffic for fourteen days.

### SECTION NO. 2

*Type*: Asphalt macadam (Penetration method).

*Thickness of Surface*: Three inches.

*Construction*: This section was constructed under the supervision of the Barber Asphalt Company, producers of the bituminous material used. The old roadway first was broomed with hand brooms and all loose or scaly material removed. Crushed limestone then was spread to a thickness approximately of three inches and rolled with a ten-ton, three-wheel roller. The grading of this course of stone was as follows:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Passing | 3″ | and | retained | on | 2″ | screen | 54.1% |
| “ | 2″ | “ | “ | “ | 1½″ | “ | 29.8% |
| “ | 1½″ | “ | “ | “ | 1¼″ | “ | 12.7% |
| “ | 1¼″ | “ | “ | “ | 1″ | “ | 2.3% |
| “ | 1″ | “ | “ | “ | ¾″ | “ | 0.8% |
| “ | ¾″ | “ | “ | “ | ½″ | “ | 0.2% |
| “ | ½″ | | | | | | 0.1% |
| | | | | | | | 100.0 |

This course required approximately 260 pounds of crushed stone per square yard. After this course had been rolled thoroughly and uniform compaction and proper grade attained, an application of hot asphalt was applied at the rate of two gallons per square yard. Fluxed Bermudez asphalt, of 120 to 150 penetration, was used on this section and was applied at a temperature of 300-325 degrees F. by means of a pressure distributor under approximately eighteen-pound pressure. The surface then

BALTIMORE-GLENBURNIE RESURFACING TEST ROAD IN MARYLAND. ASPHALT PENETRATION SECTION.

was choked or keyed with crushed limestone at the rate of 45 pounds per square yard and again rolled. The grading of this course of stone was as follows:

| | |
|---|---|
| Passing 1¼″ and retained on ¾″ screen | 19.6% |
| “ ¾″ “ “ “ ½″ “ | 64.6% |
| “ ½″ “ “ “ ¼″ “ | 15.7% |
| “ ¼ | 0.1% |
| | 100.0% |

A seal coat of one-half gallon of the same bituminous material, applied in the same manner and 40 pounds of crushed limestone per square yard then was applied, rolled thoroughly and the section opened to traffic. The grading of the stone used for seal coat was as follows:

| | |
|---|---|
| Passing ¾″ and retained on ½″ screen | 9.4% |
| “ ½″ “ “ “ ¼″ “ | 79.7% |
| “ ¼″ “ “ “ 10 mesh | 10.8% |
| “ 10 mesh | 0.1% |
| | 100.0% |

During the rolling of the first course of stone, considerable crushing under the roller was noted. An analysis on a sample of the finished pavement showed the following:

| | |
|---|---|
| Bitumen extracted | 5.3% |
| Passing 3″ and retained 2″ screen | 8.0% |
| “ 2″ “ “ 1½″ “ | 17.2% |
| “ 1½″ “ “ 1¼″ “ | 26.1% |
| “ 1¼″ “ “ 1″ “ | 12.4% |
| “ 1″ “ “ ¾″ “ | 6.9% |
| “ ¾″ “ “ ½″ “ | 6.7% |
| “ ½″ “ “ ¼″ “ | 8.9% |
| “ ¼″ “ “ 10 mesh | 4.2% |
| “ 10 mesh “ 20 “ | 1.5% |
| “ 20 “ | 2.8% |
| | 100.0% |

Analysis of the bituminous material used on this section is as follows:

| | |
|---|---|
| Specific gravity 25°C/25°C | 1.045 |
| Flash point °C | 196 |
| Penetration 25°C (gms. 100, 5 sec.) | 128 |
| Melting point °C | 42.4 |
| Ductility 25°C (cms.) | 59 |
| Loss 5 hrs., 163°C (%) | 1.05 |
| Penetration of residue 25°C, 100 gms. 5 sec. | 91 |
| Total bitumen soluble in C S 2 (%) | 94.10 |
| Organic matter insoluble (%) | 2.13 |
| Inorganic matter insoluble (%) | 3.77 |
| % Total bitumen insoluble 86° B naphtha | 20.47 |

### SECTION NO. 3

*Type*: Bitumuls (Penetration method).

*Thickness of Surface*: Two inches.

*Construction*: The surface of the old roadway first was broomed clean and then covered with crushed stone to a thickness of approximately two inches and thoroughly rolled. On the portion of the section beginning at the penetration macadam section and extending approximately 100 feet through the intersection of the old Annapolis road, the stone used was a crushed granite showing the following grading:

| | |
|---|---|
| Retained on 2″ screen | 18.5% |
| Passing 2″ retained on 1½″ screen | 25.8% |
| “ 1½″ “ “ 1¼″ “ | 18.8% |
| “ 1¼″ “ “ 1″ “ | 21.8% |
| “ 1″ “ “ ¾″ “ | 10.2% |
| “ ¾″ “ “ ½″ “ | 3.3% |
| “ ½″ “ “ ¼″ “ | 1.0% |
| “ ¼″ | 0.6% |
| | 100.0% |

This stone was utilized as a substitute after the supply used on the remainder of the section was exhausted. Apparently it was an inferior quality of stone for this work as it was not crushed with a cubical fracture and left numerous flat pieces which crushed and broke readily under the roller. The stone used on the remainder of the section was a crushed blue limestone and did not fracture under the roller to a very great extent. The screen analysis on this stone was as follows:

| | |
|---|---|
| Passing 2″ and retained on 1½″ screen | 43.1% |
| “ 1½″ “ “ “ 1¼″ “ | 40.3% |
| “ 1¼″ “ “ “ 1″ “ | 12.8% |
| “ 1″ “ “ “ ¾″ “ | 2.4% |
| “ ¾″ “ “ “ ½″ “ | .07% |
| “ ½″ “ “ “ ¼″ “ | 0.5% |
| “ ¼″ | 0.2% |
| | 100.0% |

Rolling of the coarse aggregate was continued with a ten-ton three-wheel roller until uniform compaction and proper grade were obtained. Additional stone was added where needed until a well compacted layer two inches in thickness resulted. On portions of the section where the stone crushed under the roller, a five-ton tandem roller was substituted for the ten-ton three-wheel. Approximately 20 pounds to the square yard of stone chips were spread over this surface, partially filling the voids, and then rolled with a five-ton tandem roller. These chips were crushed limestone and showed the following screen analysis:

| | |
|---|---|
| Passing ½″ screen and retained on ¼″ | 27.1% |
| “ ¼″ “ “ “ “ 10 mesh | 60.0% |
| “ 10 mesh “ “ “ 20 “ | 12.2% |
| “ 20 “ | 0.7% |
| | 100.0% |

Bitumuls was applied to this surface by means of a pressure distributor at the rate of three-fourths of a gallon per square yard. The surface then was covered with limestone screenings at the rate of 30 pounds to the square yard. The analysis of the screenings was as follows:

| | |
|---|---|
| Passing ¾″ screen and retained on ½″ | 12.8% |
| “ ½″ “ “ “ “ ¼″ | 83.4% |
| “ ¼″ “ “ “ “ 10 mesh | 3.7% |
| “ 10 mesh | 0.1% |
| | 100.0% |

This surface was broomed with a broom drag, filling in low places and dragging down the high ones until a comparatively smooth surface resulted. The surface then was rolled with a ten-ton three-wheel and a five-ton tandem roller until it thoroughly was keyed and compacted. A second application of bitumuls next was applied in the same manner and at the same rate as in the case of the first application. An application of the same rock chips that were used to fill the voids in the untreated coarse stone then was applied at the rate of 15 pounds to the square yard. The surface again was dragged with the broom drag and rolled with both rollers until thoroughly compacted.

Baltimore-Glenburnie Resurfacing Test Road in Maryland. Bitumuls Section.

Approximately two days later the surface was given a seal coat. The loose screenings on the surface were distributed by hand brooms and the broom drag. Bitumuls then was applied at the rate of four-tenths of a gallon per square yard and the surface was covered with limestone chips as before described at the rate of 15 pounds per square yard. The surface next was broomed with the broom drag and rolled thoroughly with both rollers. The roadway then was opened to traffic. On the south end of the section traffic was allowed to use the road several days before the seal coat was applied and this resulted in a slight difference in texture from the balance of the section.

### SECTION NO. 4

*Type*: Amiesite.

*Thickness of Surface*: Two inches.

*Construction*: This material was manufactured in Martinsburg, West Virginia, and shipped to the job in cars, unloaded into trucks and hauled to the roadway. The mixture consisted of an aggregate coated with bitumen and a liquefier which retarded the set of the bitumen to such an extent as to enable it to be shipped and laid cold without the application of heat. The pavement consisted of two courses, the first being a binder or base course in which a large aggregate was used. The second course was composed of a finer aggregate and was used as a surface or top for the binder course.

The old concrete roadway first was broomed clean with hand brooms and the binder course was spread to a thickness of approximately two and one-half inches before compaction. Long steel strips two and one-fourth inches wide and one-fourth of an inch thick, bent at right angles on one end in order to stand edgewise, were used on the old concrete as gauges to insure the proper thickness in the spread of the loose material. This binder course then was rolled thoroughly with a ten-ton three-wheel roller, resulting in a compacted course of between one and one-half and one and three-fourths inches. The surface or top course was spread loosely over the compacted binder course to a thickness of

BALTIMORE-GLENBURNIE RESURFACING TEST ROAD IN MARYLAND. AMIESITE SECTION.

approximately three-quarters of an inch and then rolled with a ten-ton three-wheel roller. The resultant thickness of the surface course was approximately one-half inch. No guide strips were used in laying the surface course as the mixture was so stiff and tacky that it was difficult to fill in the space occupied by the strips after they had been removed. The resultant thickness of the two compacted courses was between two and two and one-half inches. Analysis of the materials sampled from the roadway during construction was as follows:

*Binder Course*

| | |
|---|---|
| Bitumen extracted | 3.9% |
| Passing 2″ and retained on 1½″ screen | 17.1% |
| " 1½″ " " " 1¼″ " | 16.3% |
| " 1¼″ " " " 1″ " | 21.5% |
| " 1″ " " " ¾″ " | 15.3% |
| " ¾″ " " " ½″ " | 15.0% |
| " ½″ " " " ¼″ " | 6.9% |
| " ¼″ | 4.0% |
| | 100.0% |

*Surface Course*

| | |
|---|---|
| Bitumen extracted | 5.5% |
| Passing ¾″ and retained on ½″ screen | 0.8% |
| " ½″ " " " ¼″ " | 66.7% |
| " ¼″ " " " 10 mesh | 23.8% |
| " 10 mesh " " 20 " | 1.4% |
| " 20 " | 1.8% |
| | 100.0% |

On the section which measured 2969 square yards, 203 tons of binder and 98 tons of top were used. The average spread for the binder was 14.77 square yards per ton and for the top 30.3 square yards per ton.

### SECTION NO. 5

*Type*: Colprovia.

*Thickness of Surface*: Two inches.

*Construction*: This material is a composition of crushed limestone, sand, limestone dust and asphalt cement. The aggregate first was thoroughly coated with a non-volatile flux oil and to it was added a hard petroleum asphalt in a powdered state in correct proportion to ensure that, when entirely amalgamated with the flux oil, the resultant asphalt cement was of the required penetration and ductility. Fluxing action was not completed until the pavement had been consolidated by the roller and subsequent traffic. Thus it was possible for the mixture to be laid cold. The mixture was manufactured in Washington and hauled to the roadway in trucks. After the old concrete roadway had been cleaned with hand brooms, the mixture was dumped on a dump-board and shoveled and raked to grade by using a templet to secure the proper uniform grade. The mixture was spread loosely in one course to a thickness of approximately three inches and the edges were tamped with hand tamps. Rolling was done with a ten-ton tandem roller. The first rolling was parallel to the roadway but later we used the cross or angle roll. The resulting thickness of the surface after rolling was approximately two inches. Analysis on samples of the mixture collected from the roadway during construction showed the following:

Baltimore-Glenburnie Resurfacing Test Road in Maryland. Colprovia Section.

| | | | | | |
|---|---|---|---|---|---|
| Bitumen extracted | | | | | 7.5% |
| Passing | ¾″ | and retained on | | ½″ screen | 1.1% |
| “ | ½″ “ | “ | “ | ¼″ “ | 36.2% |
| “ | ¼″ “ | “ | “ | 10 mesh | 10.1% |
| “ | 10 mesh | “ | “ | 20 “ | 2.2% |
| “ | 20 “ | “ | “ | 30 “ | 1.9% |
| “ | 30 “ | “ | “ | 40 “ | 5.6% |
| “ | 40 “ | “ | “ | 50 “ | 6.8% |
| “ | 50 “ | “ | “ | 80 “ | 10.2% |
| “ | 80 “ | “ | “ | 100 “ | 3.5% |
| “ | 100 “ | “ | “ | 200 “ | 5.5% |
| “ | 200 “ | | | | 9.4% |
| | | | | | 100.0% |

Samples of the surface cut from the roadway approximately one month after completion showed an average density of 2.211. On the total section of 3059 square yards, 330.7 tons of material were used at an average spread of 9.25 square yards per ton.

### Section No. 6

*Type*: Asphaltic Concrete.
*Thickness of Surface*: Two inches.

*Construction*: This material is the regular coarse aggregate asphaltic concrete as specified under Maryland state specifications and is used quite extensively in the state for resurfacing of old concrete roads. The mixture is a standard hot-mix, hot-lay product composed of crushed limestone, sand, limestone dust and asphalt cement. The material was mixed at an asphalt plant in Baltimore, hauled directly to the roadway, dumped, spread loosely to a thickness of approximately two and three-quarter inches and rolled in the manner generally employed on this type of work. The mixture reached the road at a temperature of 275-325 degrees F. Immediately after spreading, initial compaction was obtained with a ten-ton tandem roller running parallel to the roadway. This roller was followed by a ten-ton three-wheel roller, after which some diagonal rolling was done with a tandem. After the mix had been rolled thoroughly and, while it was still warm, a squeegee seal coat was applied by using the same asphalt cement as that used in the mix, at the rate of approximately three-tenths of a gallon per square yard, and then covering it with 15 pounds per square yard of dustless stone chips of half-inch maximum size. This seal coat then was rolled thoroughly with a ten-ton three-wheel roller. The thickness of the finished surface was approximately two inches. Samples of the component parts of the mixture collected from the plant during the time of mixing showed the following results:

Baltimore-Glenburnie Resurfacing Test Road in Maryland. Asphaltic Concrete Section.

*Crushed Limestone*

| | |
|---|---|
| Passing 1¼″ and retained on 1″ screen | 9.0% |
| “ 1″ “ “ “ ¾″ “ | 39.0% |
| “ ¾″ “ “ “ ½″ “ | 33.3% |
| “ ½″ “ “ “ ¼″ “ | 15.2% |
| “ ¼″ | 3.5% |
| | 100.0% |

*Sand*

| | |
|---|---|
| Passing ¼″ screen and retained on 10 mesh | 25.0% |
| “ 10 mesh “ “ “ 20 “ | 25.5% |
| “ 20 “ “ “ “ 30 “ | 14.0% |
| “ 30 “ “ “ “ 40 “ | 13.0% |
| “ 40 “ “ “ “ 50 “ | 12.0% |
| “ 50 “ “ “ “ 80 “ | 7.0% |
| “ 80 “ “ “ “ 100 “ | 1.0% |
| “ 100 “ “ “ “ 200 “ | 2.0% |
| “ 200 | .5% |
| | 100.0% |

*Limestone Dust*

| | |
|---|---|
| Fineness (Per cent retained on 200-mesh sieve) | 2.7% |

*Asphalt Cement*

| | |
|---|---|
| Specific gravity 25°C/25°C | 1.040 |
| Flash point °C | 275 |
| Penetration 25°C, 100 gms. 5 sec | 58 |
| Melting point °C | 53.4 |
| Ductility 25°C, cms | 110 |
| Loss, 163°C, 5 hrs | .05% |
| Penetration of residue, 25°C, 100 gms. 5 sec | 53 |
| Total bitumen (sol. CS2) | 99.82% |
| Organic matter insoluble | .18% |
| Per cent of total bitumen insol. 86 B naphtha | 25.25 |
| CC ¼ insoluble | 0.0 |

Samples of the mixture collected at the roadway during construction showed the following analysis:

| | |
|---|---|
| Bitumen extracted | 5.4% |
| Passing 1¼″ screen and retained 1″ | 5.4% |
| “ 1″ “ “ “ ¾″ | 23.1% |
| “ ¾″ “ “ “ ½″ | 19.7% |
| “ ½″ “ “ “ ¼″ | 9.1% |
| “ ¼″ “ “ “ 10 mesh | 2.1% |
| “ 10 mesh “ “ 20 “ | 2.2% |
| “ 20 “ “ “ 30 “ | 1.2% |
| “ 30 “ “ “ 40 “ | 4.3% |
| “ 40 “ “ “ 50 “ | 6.0% |
| “ 50 “ “ “ 80 “ | 8.8% |
| “ 80 “ “ “ 100 “ | 2.7% |
| “ 100 “ “ “ 200 “ | 3.3% |
| “ 200 | 6.7% |
| | 100.0% |

Samples of the finished surface cut from the roadway approximately one month after construction showed an average density of 2.337. On the entire section of 3204.5 square yards, 379 tons of material were used. The spread was at the rate of 8.45 square yards per ton.

### SECTION NO. 7

*Type*: Macasphalt.

*Thickness of Surface*: One and one-half inches.

*Construction*: This mixture was composed of a uniformly-graded crushed granite and an asphalt cement. The asphalt cement was a composition of a hard Cuban asphalt fluxed with a topped Mexican crude oil. The mixture was manufactured in such a manner as to retard its setting or becoming hard, thus enabling it to be shipped and laid cold. After thoroughly brooming all loose material from the base the mixture was unloaded from the cars to trucks by means of a clam shell and hauled to the roadway and dumped on the base. The material then was shoveled into place and raked to proper grade. Two and one-half inch steel strips were used as depth gauges as described previously. Short hand lutes were used on top of the steel strips and all excess material was removed. The steel strips then were removed and the surface was rolled with a ten-ton three-wheel roller parallel with the roadway. The following day the surface was cross and angle rolled with a five-ton tandem roller and the section was opened to traffic.

BALTIMORE-GLENBURNIE RESURFACING TEST ROAD IN MARYLAND. MACASPHALT SECTION.

An analysis of the material taken from the roadway during construction showed the following:

| | | | | | | |
|---|---|---|---|---|---|---|
| Bitumen extracted | | | | | | 7.8% |
| Passing | ½" | screen | and retained | on | ¼" | 4.6% |
| " | ¼" | " | " | " | 10 mesh | 20.5% |
| " | 10 mesh | " | " | " | 20 " | 14.9% |
| " | 20 " | " | " | " | 30 " | 6.0% |
| " | 30 " | " | " | " | 40 " | 7.9% |
| " | 40 " | " | " | " | 50 " | 6.0% |
| " | 50 " | " | " | " | 80 " | 8.8% |
| " | 80 " | " | " | " | 100 " | 3.6% |
| " | 100 " | " | " | " | 200 " | 7.0% |
| " | 200 | | | | | 12.9% |
| | | | | | | 100.0% |

A sample removed from the compacted surface approximately two weeks after completion of the section showed a density of 2,159. On the entire section, consisting of 2,969 square yards, a total of 219.5 tons of material was used, with an average spread of 13.52 square yards per ton.

Baltimore-Glenburnie Resurfacing Test Road in Maryland. Asbestophalt Section.

### Section No. 8

*Type*: Asbestophalt.

*Thickness of Surface*: One and one-half inches.

*Construction*: This mixture was a standard stone-filled sheet asphalt mixture in which asbestos fiber had been substituted for the limestone dust or filler. The mix was composed of proportionate parts of crushed limestone, sand, asbestos fiber and asphalt cement. The material was mixed hot, at an asphalt plant in Baltimore and hauled in trucks to the roadway. The old concrete roadway first was broomed clean and then was painted with a light coat of cut-back asphalt. The headers were painted with an asphalt cement of the quality used in the mix. The material reached the roadway at a temperature of 325-400 degrees F., was dumped, shoveled into place and spread by the use of rakes at the rate of 150 pounds to the square yard. For these conditions this gave a thickness of approximately three and one-half to four inches before compression. The edges were tamped by means of hot hand-tamps. Rolling was done with a ten-ton three-wheel gasoline roller which progressed parallel to the roadway. The section was opened to traffic on the following day.

Analysis of the component parts of the mixture was as follows:

*Crushed Limestone*

| | |
|---|---|
| Passing ½″ and retained on ¼″ screen | 19.9% |
| “ ¼″ “ “ “ 10 mesh | 71.1% |
| “ 10 mesh “ “ 20 “ | 8.5% |
| “ 20 “ | 0.5% |
| | 100.0% |

*Sand*

| | |
|---|---|
| Passing ¼″ screen and retained on 10 mesh | 1.0% |
| “ 10 mesh “ “ “ 20 “ | 5.5% |
| “ 20 “ “ “ “ 30 “ | 4.6% |
| “ 30 “ “ “ “ 40 “ | 16.8% |
| “ 40 “ “ “ “ 50 “ | 20.6% |
| “ 50 “ “ “ “ 80 “ | 29.2% |
| “ 80 “ “ “ “ 100 “ | 8.7% |
| “ 100 “ “ “ “ 200 “ | 9.1% |
| “ 200 “ | 4.5% |
| | 100.0% |

*Asbestos Fiber*

| | |
|---|---|
| Matter insoluble in H C L (%) | 82.31 |
| Loss on ignition (%) | 11.47 |

*Asphalt Cement*

| | |
|---|---|
| Specific gravity 25°C/25°C | 1.020 |
| Flash point °C | 310 |
| Penetration 25°C, 100 gms., 5 sec. | 57 |
| Melting point °C | 52.8 |
| Ductility 25°C, cms. | 110+ |
| Loss, 163°C, 5 hrs. (%) | .04 |
| Penetration of residue, 25°C, 100 gms. 5 sec. | 50 |
| Total bitumen (Sol $CS_2$) (%) | 99.68 |
| Organic matter insoluble (%) | 0.26% |
| Inorganic matter insoluble (%) | .06 |
| % of total bitumen insol. in 86° B naphtha | 21.55 |
| C C 1 4 insoluble | 0.0 |

Analysis of the mixture collected from the roadway during construction showed the following:

| | |
|---|---|
| Bitumen extracted | 12.3% |
| Passing ¼″ and retained on 10 mesh | 8.1% |
| " 10 mesh " " 20 " | 4.3% |
| " 20 " " " 30 " | 2.9% |
| " 30 " " " 40 " | 9.2% |
| " 40 " " " 50 " | 14.3% |
| " 50 " " " 80 " | 21.9% |
| " 80 " " " 100 " | 5.6% |
| Passing 100 mesh and retained on 200 mesh | 4.9% |
| " 200 " | 4.3% |
| Asbestos | 8.8% |
| Loss | 3.4% |
| | 100.0% |

A sample of the surface of the roadway removed the day following construction showed a density of 2.077. On the entire section, totalling 2,969 square yards, 223 tons of material were used at an average spread of 13.31 square yards per ton.

## SECTION NO. 9

*Type*: Westphalt.
*Thickness of Surface*: One and one-half inches.

*Construction*: This mix was composed of a uniformly-graded crushed limestone, combined with a hard gilsonite in a powdered state, and a fluxing oil. During the process of manufacture the materials were cold

BALTIMORE-GLENBURNIE RESURFACING TEST ROAD IN MARYLAND. WESTPHALT SECTION.

enough when combined so as to prevent the blending of the gilsonite and fluxing oil. The material then was shipped to the site where it was to be used and heated in a concrete mixer specially equipped with oil burners. It was laid hot. After thoroughly brooming the base a light application of cut-back asphalt was applied particularly on that portion of the old concrete that had not been patched. The mixture was then heated in the concrete mixer to a temperature of 275-350 degrees F. and dumped on a dumping board, shoveled into place and raked to grade. The surface then was rolled thoroughly with an eight-ton tandem roller, first by rolling parallel with the headers and later by angle rolling. Analysis of the material taken from the roadway during construction was as follows:

| | |
|---|---|
| Bitumen extracted | 7.3% |
| Passing ½″ screen and retained on ¼″ | 9.4% |
| " ¼″ " " " " 10 mesh | 31.5% |
| " 10 mesh " " " 20 " | 15.3% |
| " 20 " " " " 30 " | 4.2% |
| " 30 " " " " 40 " | 3.6% |
| " 40 " " " " 50 " | 2.2% |
| " 50 " " " " 80 " | 3.6% |
| " 80 " " " " 100 " | 1.9% |
| " 100 " " " " 200 " | 4.1% |
| " 200 | 16.9% |
| | 100.0% |

Samples cut from the finished pavement approximately two weeks after construction showed an average density of 2.331. On the entire section of 3073.8 square yards, 242 tons of material, all told, were used. The average spread was 12.7 square yards to the ton.

### SECTION NO. 10

*Type*: Bituroc (Kentucky rock asphalt).

*Thickness of Surface*: One and one-half inches.

*Construction*: The material in its native state consisted of siliceous sand impregnated with asphalt, the combination having been consolidated into a rock-like formation. The finished product consisted of selected rock asphalt which had been quarried and subsequently crushed and pulverized. This pulverized material was seasoned by storage before being shipped to the paving project where it was to be used. An analysis of the material sampled from the roadway during construction showed the following:

| | |
|---|---|
| Extracted bitumen | 6.4% |
| Passing 10 mesh and retained on 20 mesh | 0.8% |
| " 20 " " " " 30 " | 0.6% |
| " 30 " " " " 40 " | 1.7% |
| " 40 " " " " 50 " | 8.1% |
| " 50 " " " " 80 " | 50.7% |
| " 80 " " " " 100 " | 12.8% |
| " 100 " " " " 200 " | 12.0% |
| " 200 | 6.9% |
| | 100.0% |

Moisture in sample ........................................ 3.0

After a thorough brooming, the base was painted with a light application of asphalt cut-back at the rate of one tenth (.1) gallon per square yard. The material was unloaded from railroad cars by means of a clam shell and hauled to the roadway where it was spread loosely to a uniform thickness of two and one-quarter inches, using the same steel guide-strips and lutes as heretofore described. The surface then was rolled once over by lapping one-half width of the rear wheel of a ten-ton roller. On the following day the surface again was rolled once, parallel to the center-line, with a five-ton tandem roller. The section then was opened to traffic.

BALTIMORE-GLENBURNIE RESURFACING TEST ROAD IN MARYLAND. BITUROC SECTION.

After supplying 200 feet on the south end of this section it was found that the rate of application could be accelerated by employing steam jets in the railroad cars to heat the material before unloading. The heated material required less manipulation and this method was continued for the remaining 1,500 feet of the section.

On this entire section, which included 2,969 square yards, 210 tons of material were used. The average spread was 14.14 square yards per ton.

### SECTION NO. 11

*Type*: Kyrock.
*Thickness of Surface*: One and one-half inches.

*Construction*: This material was of a character similar to that used on Section 10. It occurs in the Pottsville sands in Kentucky and is mined and manufactured similar to the other material. This material was not warmed, however, before construction. It was laid cold. After brooming the base and painting with a thin coat of cut-back asphalt the material was dumped and spread loosely to a uniform thickness of two and one-quarter inches by using the two and a-half inch steel strips as depth guides. The hand lutes were used parallel to the roadway to remove all excess material over and above the thickness of the strips. A larger lute then was used at an angle over the surface in order to fill in the low spots and, particularly, the openings left after the guide-strips were removed. The rolling was done with a ten-ton, three-wheel roller, parallel to the roadway. The following day the surface was angle rolled with a five-ton tandem roller and the section opened to traffic. Analysis of this material collected from the roadway during construction and as submitted by the producer, was as follows:

| | |
|---|---|
| Bitumen extracted | 7.0% |
| Passing 10 mesh and retained on 20 mesh | 0.8% |
| “ 20 “ “ “ “ 30 “ | 1.0% |
| “ 30 “ “ “ “ 40 “ | 5.9% |
| “ 40 “ “ “ “ 50 “ | 17.3% |
| “ 50 “ “ “ “ 80 “ | 42.0% |
| “ 80 “ “ “ “ 100 “ | 8.9% |
| “ 100 “ “ “ “ 200 “ | 8.6% |
| “ 200 | 8.5% |
| | 100.0% |

The loss on ignition was found to be 7.1%. On the entire section of 2,969 square yards, 197 tons of material were used, with an average spread of 15.32 square yards per ton.

### Section No. 12

*Type*: Slagmac.

*Thickness of Surface*: Two inches.

*Construction*: This surface consisted of a two-course pavement in which slag was used as the aggregate and an especially prepared, refined coal tar was used as the bitumen, the material being laid cold. The old concrete roadway first was broomed and all loose material was removed. The binder or base course was spread loosely to a uniform thickness of two inches by using the steel strips to obtain proper depth and grade. Rolling first was attempted with a ten-ton three-wheel roller but, due to the slag crushing under the weight, a five-ton tandem roller was used. After this course had been rolled thoroughly and had compacted it showed an average thickness of approximately one and one-half to one and three-fourths inches. The surface or wearing course then was spread loosely on this compacted base course to a uniform thickness of three-quarters of an inch by using three-quarter inch bars laid parallel to the roadway on top of the binder course to serve as depth and grade gauges. This surface then was thoroughly rolled with the ten-ton three-wheel roller for initial compression and the five-ton tandem roller for angle rolling or smoothing. The two compacted courses showed a final thickness of from two to two and one-half inches. The analysis that was made of the materials sampled from the roadway during the construction was as follows:

*Base Course*

| | |
|---|---|
| Bitumen extracted | 4.4% |
| Passing 2″ screen and retained on 1½″ | 8.9% |
| “ 1½″ “ “ “ “ 1¼″ | 17.7% |
| “ 1¼″ “ “ “ “ 1″ | 34.1% |
| “ 1″ “ “ “ “ ¾″ | 21.9% |
| “ ¾″ “ “ “ “ ½″ | 6.8% |
| “ ½″ “ “ “ “ ¼″ | 3.7% |
| “ ¼″ | 2.5% |
| | 100.0% |

*Surface or Wearing Course.*

| | |
|---|---|
| Bitumen extracted | 6.0% |
| Passing ½″ screen and retained on ¼″ | 69.9% |
| “ ¼″ “ “ “ “ 10 mesh | 21.9% |
| “ 10″ mesh “ “ “ 20 “ | 0.7% |
| “ 20″ “ “ “ “ 30 “ | 0.2% |
| “ 30″ “ “ “ “ 40 “ | 0.2% |
| “ 40″ “ “ “ “ 50 “ | 0.1% |
| “ 50″ “ “ “ “ 80 “ | 0.2% |
| “ 80″ “ “ “ “ 100 “ | 0.1% |
| “ 100″ “ “ “ “ 200 “ | 0.2% |
| “ 200″ | 0.5% |
| | 100.0% |

On this section of 2969 square yards, a total of 205 tons of binder and 93.5 tons of top were used. The average spread was 14.48 square yards per ton for the binder and 31.75 square yards per ton for the surface. Approximately one month after the Slagmac section had been opened to traffic, a seal coat of asphalt, consisting of eight-tenths of a gallon per square yard was applied and covered with coarse sand.

### SECTION NO. 13.

*Type*: Tarmac.

*Thickness of Surface*: Two inches.

*Construction*: This surface consisted of two courses, a binder or base course and a wearing or surface course. The mixture was composed of a uniformly-graded crushed limestone in which an especially prepared, refined coal tar was used as the bituminous material, the surface being laid cold. The binder course was spread loosely to a uniform thickness of approximately two inches and rolled with a five-ton, three-wheel roller. This course showed a thickness of one and a half to one and three-quarters inches after compaction. The wearing course was spread loosely over the compacted base course to a uniform thickness of three-fourths of an inch and rolled with a ten-ton, three-wheel roller and a five-ton, three-wheel roller. Rolling was continued intermittently for a period of three days until this mixture was compacted and hardened. The resultant thickness of this wearing course was approximately one-half inch. The section was opened to traffic for approximately one week, after which the surface was given a filler course composed of sand containing a very low percentage of tar. This material was cast over the surface of the roadway with shovels and rolled lightly. The object of this was to fill the voids and close the surface. The total compacted thickness of the two courses was approximately two inches. An analysis of the materials collected from the roadway during construction showed the following:

*Base Course.*

| | |
|---|---|
| Bitumen extracted | 2.5% |
| Passing 1¼″ screen and retained on 1″ | 28.6% |
| " 1″ " " " " ¾″ | 42.7% |
| " ¾″ " " " " ½″ | 11.2% |
| " ½″ " " " " ¼″ | 7.8% |
| " ¼″ " " " " 10 mesh | 3.7% |
| " 10 mesh | 3.5% |
| | 100.0% |

*Surface Course.*

| | |
|---|---|
| Bitumen extracted | 3.4% |
| Passing ½″ screen and retained on ¼″ | 76.4% |
| " ¼″ " " " " 10 mesh | 18.3% |
| " 10 mesh | 1.9% |
| | 100.0% |

On this section, which embraced 3019 square yards, 222.5 tons of binder and 125.5 tons of surfacing materials were used, at an average spread of 13.56 square yards per ton for the binder and 24.05 square yards per ton for the wearing course.

## SECTION NO. 14

*Type*: Tarvialithic.

*Thickness of Surface*: Two inches.

*Construction*: This pavement consisted of two courses,—a base or binder course and a wearing course. The mixture was composed of a uniformly graded traprock in which a specially prepared straight-run tar was used as the bitumen, the material being laid cold. After thoroughly brooming the base the binder course was spread loosely to a uniform thickness of two inches. The steel strips again were used to secure the proper grade and thickness. This course then was rolled thoroughly with a ten-ton, three-wheel roller. After compaction, it showed a thickness of one and one-half to one and three-quarter inches. The wearing course was spread loosely over the compacted binder course to a uniform thickness of three-quarters of an inch, by using three-quarter inch bars to secure the proper grade and thickness. After these bars were removed the space occupied by them was filled with the mixture and the surface was rolled thoroughly with the ten-ton, three-wheel roller. The resultant thickness of this course was approximately half an inch, making a total thickness for the surface of two, to two and one-quarter inches. Analysis of the mixtures as collected from the roadway at the time of construction showed the following:

*Binder Course.*

| | |
|---|---|
| Bitumen extracted | 2.3% |
| Passing 1¼″ screen and retained on 1″ | 23.9% |
| " 1″ " " " " ¾″ | 32.3% |
| " ¾″ " " " " ½″ | 30.8% |
| " ½″ " " " " ¼″ | 7.2% |

| | |
|---|---|
| “ ¼″ “ “ “ “ 10 mesh | 1.2% |
| “ 10 mesh | 2.3% |
| | 100.0% |

*Wearing Course.*

| | |
|---|---|
| Bitumen extracted | 6.5% |
| Passing ½″ screen and retained on ¼″ | 41.9% |
| “ ¼″ “ “ “ “ 10 mesh | 35.7% |
| “ 10 mesh “ “ “ 20 “ | 5.4% |
| “ 20 “ “ “ “ 30 “ | 1.6% |
| “ 30 “ “ “ “ 40 “ | 1.6% |
| “ 40 “ “ “ “ 50 “ | 1.1% |
| “ 50 “ “ “ “ 80 “ | 1.7% |
| “ 80 “ “ “ “ 100 “ | 0.7% |
| “ 100 “ “ “ “ 200 “ | 1.4% |
| “ 200 | 2.4% |
| | 100.0% |

On this section of 2969 square yards, 236 tons of binder and 113 tons of surfacing material were used, showing an average spread of 12.54 and 26.27 square yards per ton respectively.

## DISCUSSION.

CHAIRMAN LYON: I think you will agree with me that this committee report has been a very important work. It shows a cross-section of the practice of resurfacing old roads and gives some very valuable conclusions. We would like to hear from the other members of the committee. Mr. Paul N. Coats, county engineer at St. Paul, Minn., has something to say.

MR. PAUL N. COATS, St. Paul, Minn.: Mr. Chairman, I think Mr. Raschig and his committee are entitled to very favorable comment for their preparation of this report, particularly in regard to the conclusions, which are numerous and which cover the field entirely. This committee on resurfacing would like to see a standard practice developed as far as it is possible. The report has to do with the resurfacing of all types of surfaces, particularly gravel, macadam, brick, cobblestone and concrete. Let us encourage discussion at this meeting. Although you may feel that your comments may be of a local nature and might approach an aspect of criticism, we wish to encourage your participation. My comments apply particularly to highways rather than streets. I would like to see developed in the discussion things of a more specific nature, and at the risk of departing from generalities, I wish to comment shortly on the resurfacing of oiled gravel roads.

The oiled gravel roads with which I have been most familiar have been developed over a period approximately of eight years, ranging, in different roads, from two to eight years of oil application on gravel, with the resurfacing of the gravel approximately every two years. The result, after a period of years, was a very substantial road surface in the form of encrusted gravel. We realized that there was a great and valuable investment in such a surface that should be saved. The roadway carefully was formed as to cross-section and profile in the hope of developing a method of resurfacing for these roads without the necessity of continual applications of new gravel. Gravel in our territory rapidly is petering out and it is necessary to conserve as much as possible of that material. When the cold asphalts were developed experimental applications of cut-backs and tars were made over a few selected types of surfaces. While I appreciate that this discussion might overlap the work of the committee on "mixed-in-place" methods, I shall give briefly some of the costs and quantities of the work over a period of three years which we have done in our locality.

In 1928 we resurfaced 190,000 square yards, in 1929 205,000 square yards, and in 1930, 205,000 square yards of oiled gravel roadway. The lowest cost per mile in 1928 was $870; that in 1929 was $800, and that in 1930, $1268. I might say that one of the reasons for having such a low cost in 1928 was that our first applications that year were made as cheap as possible in the hope of developing a failure that would indicate how much more material and workmanship might be needed in applying something which we would feel would be entirely satisfactory. The average cost for 1928 was $1322 per mile. In 1929 it was $1650 and in 1930, $1656. You will note that there has not been a great deal of difference between the average cost per mile in 1929 and that of 1930, although there has been a great deal of difference in the value of the surface we have succeeded in getting.

The reason I give you square yards rather than miles is that we found in the first year's application that we figured our surface too narrow and left an edge which developed raveling, and in order to prevent this raveling we went clear out to the grassy shoulders on the roadside, thus increasing the yardage. The lowest cost per square yard in 1928 was 7½ cents. In 1929 it was 7.6 cents and in 1930, 10.2 cents. The highest cost was 21.8 cents in 1928. In 1929 it was 17.4 cents and in 1930, 16.8 cents. The average cost of the annual applications of surface treatment in 1928 was 28.12 cents. In 1929 it was 12.4 cents and in 1930, 13.6 cents.

I might say, in regard to the aggregate used in our resurfacing work, that we tried experiments with various types of aggregate such as sand, a mixture of sand and gravel, mixtures of gravel of all sizes up to the inch-and-a-half material and pea gravel or rock gravel, so called, of the smaller sizes, both clean and in combination with sands, limestones and traprocks. The work, we thought, was of an experimental nature, so we observed and noted the various combinations and confined them to specific locations on the roads. We have developed the fact that even though the cost is much more for a hard aggregate such as traprock, we have established the standard of using nothing else but traprock. At the present time we use nothing but ⅝ inch traprock, graded and screened, at a cost of $1.60 per ton at the unloading point on the cars. The average number of pounds used in 1928 was 38 to the square yard. In 1929 it was fifty, and in 1930, fifty-two.

I referred to cut-back asphalts. While we use road oils in combination with cut-back asphalt, we have also used liquid asphalt, asphalt cut-back and oil cut-back. The figures are mentioned as though they were for the cut-back entirely. The quantity used in 1928 was ½ gallon to the square yard. In 1929 it was .63 of a gallon, and in 1930 it was .7 of a gallon. So you see we have increased the quantities of materials very definitely but we have not increased the price to any great extent. We have, however, probably increased the value of our road surface three or four hundred per cent.

I notice that the report of the committee did not make any mention as to the resurfacing of wood block pavements. It has been my observation in different localities that something is quite necessary to correct certain conditions existing in the surface of wood block pavements. Possibly the answer has not yet been found. I know of instances where many experiments have been tried but where no satisfactory solution has been found, and I hope that in this discussion you will give your suggestions as to the surface treatment of that type of road.

CHAIRMAN LYON: I think Mr. B. E. Gray, highway engineer of The Asphalt Institute, has a few remarks to make.

MR. B. E. GRAY, New York City: I just wanted to state that Col. Williar or Mr. Reindollar of Maryland had expected to be here and present the report of their experimental road in Maryland, where they are trying a number of different bituminous types over old concrete in cooperation with the United States Bureau of Public Roads. These will be kept under observation for a number of years and reports will be made on them from time to time.

CHAIRMAN LYON: We would like very much to have some further discussion on this very valuable subject.

MR. HENRY L. HOWE, Rochester, N. Y.: Mr. Chairman, I was somewhat surprised to hear the rather strong conclusion in the committee's report that it is necessary for the successful resurfacing of brick, block and other pavements to use a surface heater. I think that conclusion is slightly arbitrary myself, judging from our experience. I do not question the value of the surface heater in resurfacing work where it is necessary under damp conditions, but we have successfully resurfaced many brick, block and macadam pavements, as well as other types, without having a surface heater on the job. In those cases we always used the cut-back naphtha for the binder where we do not use the stone binder. I would like to ask the committee on what data it bases such a conclusion?

MR. RASCHIG: Well, I don't know, I think perhaps you misunderstand. The conclusion reached was that with a thin top it is far better to use the heater. In a great many states they use a thin top or a feather edge, and it won't stick unless something is done to take care of that. We think the proper thing to do is to use a surface heater.

MR. HOWE: I would like to invite you to Rochester where we regularly thin-patch our bituminous pavements, anywhere from a feather edge to an inch of asphalt, without using a surface heater and without using a binder.

MR. RASCHIG: We refer more particularly to concrete or granite block, or something like that. With macadam I don't think it is necessary.

MR. J. T. BULLEN, Shreveport, La.: I would like to say that down in Louisiana we have been considering using some sort of cooling system.

MR. G. H. LUTZ, Philadelphia, Pa.: Mr. Chairman, may I say a word please? There has been some mention here by several gentlemen regarding the use of the pavement heater method for fastening asphalt onto the old surface. Having been engaged in this work for over twenty-five years I would like to tell you that during this last year the City of Philadelphia has resurfaced something like a half million square yards by heating and then coating the old pavement with asphalt cement and then laying the top on that under the regular specifications of the city. The City of Minneapolis has resurfaced more than 50,000 yards of wood block pavements with the heater method; that is, by vulcanizing the asphalt wearing surface onto the old wood block pavement. Many of the states have done a great deal of this work.

I do not do the work myself. I am not a contractor. I simply furnish the pavement heaters. I merely tell you this as a matter of information. Up in Massachusetts a contractor has very successfully resurfaced old macadam roadways. You would never know that the new pavement had been vulcanized on the old pavement or road because there are no faults in the pavement. There has been no creeping, shoving or any other kind of disintegration. I brought with me a core drilled out of a concrete pavement in the City of Philadelphia by the highway department in one of its tests. At the close of the meeting if anybody would like to look at it I would be glad to show it to him. It had been down about five years I was told. If you care for any information on the subject, I would be pleased to give it.

**Mr. Arthur H. Blanchard**, Toledo, O.: I trust that the gentleman from Rochester will give me what information he has along the line of the following queries: First, the report refers to resurfacing concrete pavements when they are worn out. This is a very admirable idea; otherwise they will pass to the lower regions. But the point is you have mentioned six or eight years. Does the committee mean that the pavements are worn out so that they are of no further use, or does it mean that from six to ten years is considered the proper life of concrete prior to resurfacing? Second, you have mentioned several cases of failure in resurfacing old concrete. Have you information so that you can state positively that those failures occurred not because the old concrete was in such rotten shape that it could not be surfaced satisfactorily as a foundation?

This subject, gentlemen, of the resurfacing of concrete pavements is one which, from the Canadian border to the Gulf of Mexico and from the Atlantic to the Pacific coasts, is going to be one of the greatest and most important economic problems that the highway engineers of this country will have to face, because all over the country there are hundreds of thousands of square yards of concrete pavement now ready for resurfacing. Unfortunately the Portland Cement Association has conducted its business on the same theory that Barnum did, which was that "a sucker is born every minute." Therefore you will find today brand new municipal engineers, county engineers and even state engineers who will believe every word of the propaganda of the Portland Cement Association to the effect that the present concrete pavements will still be in existence in the days of the children of our grandchildren.

Just one example and then I am through. I was called in consultation to a city in Wisconsin, where the city engineer had followed the uneconomic practice of laying concrete pavements on a city street, flush with railway tracks. Practically every franchise issued to a street railway company requires the company to place its rails at grade and thereafter the expense of changing is up to the municipality. Now, what was the result in this city in Wisconsin? Well, the concrete pavement had become "shot to pieces"—you know what I mean—in a period of four years, and what did the city want to do? The officials wanted to resurface and put on an asphaltic pavement. But how could they? The concrete was flush with the rails. They told the railway company that it must raise its rails two inches. And what did the street railway company do, composed, as it was, of men of vision not only in engineering but in economic and business problems? Well, politely the railway company told the city officials "to go to ——," and you know the place. Then they took it to court and the court supported the railway company of course. It was clear cut. Next the city officials offered to pay the company to raise the rails, and the company officials, in court again, stated that they were perfectly satisfied where their rails were. They were on a good foundation, they said, and to raise them two inches would be very detrimental to the future life of the track. You know, gentlemen, we all make mistakes; there are none of us who are infallible, but the fool is he who makes the same mistake right over again. That city engineer took a big crane with a heavy iron weight, smashed up that concrete pavement and threw it way. Then he laid another concrete pavement flush with the rails.

MR. RASCHIG: I might say this report is just a survey of what is being done. We have not argued the relative merits of concrete and asphalt pavements and things like that.

CHAIRMAN LYON: Any further discussion?

MR. WALTER A. HEIMBUECHER, University City, Mo.: Mr. Chairman: I resurfaced a short piece of old concrete which has been down about eight years, using asphalt as a tack coat. The traffic was fairly heavy on it. The pavement was swept clean by the fast traffic and I did not even have to put a broom on it to clean it. The resurfacing has been down now about four months and I have not seen any indications of raveling at all. It is sticking very well. The top was "retread" mixed in place from about three-quarters of an inch to two inches thick. I did not find it necessary to use the heater. The pavement was clean, the oil there being only a very small amount, in fact just the usual drippings and an unappreciable amount.

CHAIRMAN LYON: If there is no further discussion we will go on with the next paper, a "Survey Report of the Committee on Pavement Widening" by Mr. B. E. Gray, highway engineer of The Asphalt Institute, New York.

# Survey Report of the Committee on Pavement Widening

## By Bernard E. Gray, New York, N. Y.

*Chairman*

Yesterday I happened to read in a newspaper a review of a recent legal decision which is pertinent to this report. I wondered a little as to what the feeling of the defendant was when the decision was handed down.

The decision was that the driver of a motor car is liable for injuries to a passenger caused by the overturning of the car when it runs off the edge of the pavement. We all have seen the shoulder conditions adjacent to certain rigid types of pavement in the spring of the year. We have all seen those deep ruts and we wonder just a little bit as to what due care can be exercised when the front wheel drops over the edge. Such accidents cost a lot of money. In this case that I refer to it cost the life of an individual. A great many such accidents as this are constantly taking place.

Narrow pavements are a source of danger. They prevent the effective development of an area because of the inefficient use of the transportation system. The question presents itself, how to widen these pavements so as to conserve all previous investment and, at the same time, provide facilities adequate for modern needs. It is hard to draw the line between resurfacing and widening, as they frequently go hand in hand. The report of this committee, therefore, may partially overlap that of the one on the former subject.

This report is based on returns from a series of questionnaires sent to the forty-eight highway departments. Returns were received from practically all the departments, indicating that the work of widening has been carried on to some extent throughout the country. It long has been recognized that a certain minimum width should obtain for the travelled way on one-lane, two-lane, three-lane and four-lane roads, but for one reason or another many surfaces, even on the most important routes, have been constructed with less than the prescribed minimum.

Concrete Pavement Widened with Asphaltic Oil-Treated Gravel Shoulders. Note Absence of any Rut at Edge of the Concrete.

## SERIOUS CONDITION GROWING OUT OF NARROW ROADS.

One of the leading highway engineers in the East, even as recently as five years ago, stated, in answer to the criticism that his state roads were too narrow: "Well, what we put on the side we have to take off the end, and with a fifteen-foot roadway instead of one that is eighteen or twenty feet wide we obtain six miles instead of five for the same money." This policy, either by design or accident, has created a condition which now requires serious attention, especially where the rigid types of surfacing have been employed.

One of the most vulnerable points in a pavement is the edge and where traffic volume has grown so that it flows over the edge, maintenance costs rapidly increase, while the hazard to the vehicle and to human life increases as well. These costs do not always show in the pavement maintenance under some forms of accounting, being camouflaged under shoulder and roadway maintenance, but the increase is almost entirely attributable to the narrow road surface. In the rainy seasons of the year, especially during the spring months, the hazard to human life is especially high because of the deep ruts which form at the edge of narrow pavements. Accidents increase substantially at this season of the year. The wear on the pavement surface also increases, due to the concentration of traffic in a narrow lane, through fear of the edge, instead of dispersing freely over the full width of the road.

## METHODS EMPLOYED FOR WIDENING NARROW ROADS.

This condition generally is recognized by all engineers. The difficulty is to obtain the additional width at a reasonable cost. A description of a number of successful plans employed at widely divergent points in the United States should be of value to officials everywhere and the report of the committee accordingly is devoted to this purpose. There are three principal methods employed as follows:

(1) Placing additional width of pavement of the same or similar type.

(2) Placing a course adjacent to the present pavement and of the same height, followed by laying a new top course over the old pavement as well as the widened area to obtain an entirely new surface.

(3) Treatment of the berms so as to permit turning out and back, but with the bulk of the traffic carried on the old pavement.

All three methods have been employed with marked success and the practice is rapidly increasing. Even with new construction where the two-lane roadway width is twenty feet, it has been found desirable to treat the berms, partly for lower maintenance costs which have resulted through prevention of erosion but particularly because of parking regulations which prohibit stopping on the pavement. It is recognized that a large number of highway accidents are due to vehicles parked on the pavement, necessitating quick turn-outs by following cars and consequent collisions. If such parking regulations are to be enforced, public authorities must provide a berm of such character as will permit easy driving on and off at all seasons of the year.

From Table I, appended hereto, it is evident that the majority of the states are finding that, by using the asphaltic types, pavements may be widened at the lowest cost consistent with good results. A detailed description of all the methods used would be unending, but the following are given because they are representative of average conditions:

### METHODS USED IN CALIFORNIA.

Mr. C. H. Purcell, state engineer of California, reports: (a) A total of 135 miles of penetration macadam widened and the whole resurfaced with asphaltic concrete. (b) A total of 395 miles of old concrete widened and the whole resurfaced with asphaltic concrete. (c) Cost per ton (complete in place) of asphaltic concrete $4.50. (d) Due to use of machine spreaders and finishers in asphaltic concrete work, the daily tonnage has increased from 300 tons to 1,000 tons per paving unit and the roughness has decreased from 20″ per mile in 1927 to but 8″ per mile in 1930. These extraordinary results must be seen to be appreciated. (e) Practically all gravel or stone widening is treated with asphaltic oil. From 1928-1930, 226 miles of oil mix or cut-back asphalt mix gravel and stone shoulders were constructed. (f) From 1928-1930, 460 miles of natural soil shoulders from 3 to 6 feet wide were oiled. (g) Costs: penetration macadam, 2 inches thick—45c per sq. yd.; asphaltic concrete, 2 inches thick—55c-60c per sq. yd.; gravel or stone shoulders (asphaltic mix), 4 inches thick—55c per sq. yd.; oiled natural earth shoulders (either by penetration or mixing)—5c per sq. yd.

CONCRETE ROAD IN MASSACHUSETTS WIDENED WITH ASPHALT MACADAM PREPARATORY TO RESURFACING.

While maintenance costs in California have remained practically unchanged in total amount, the roadway widths have been increased from

26 feet to 36 feet, so that actually, costs, per transverse foot of roadway, have been reduced.

### METHODS EMPLOYED IN CONNECTICUT.

Mr. George E. Hamlin, state superintendent of repairs in Connecticut, states: "It is not practical to rebuild all old roads to their ultimate width immediately. The available funds require a wholesale method of widening at the lowest cost, to allow a balance for reconstruction in the most congested areas. With these conditions in mind, the maintenance department has been endeavoring by treatment of the shoulders to give the additional width required for travel and reduce the need for continued maintenance. . . . Shoulders are first graded to conform to uniform cross-section of the pavement and then treated with 45 per cent road oil at the rate of about ½ gallon per square yard. They are then "honed" (dragged) thoroughly to mix the soil and bitumen. If the material is particularly sandy, the first application is followed by a second and third, until a mixture from 2½ inches to 3 inches deep is obtained. . . . Gravel can be successfully compacted in this manner. . . . We have found that the actual maintenance cost after shoulders have received a bituminous treatment is reduced below the cost of the untreated shoulders. The total maintenance cost in the state with traffic doubling in the past six years has varied but little. There has been a distinct reduction in the cost of maintenance of the pavement, as the breaking down of the edges largely has ceased and the greater part of the water conditions under the travel path (pavement), due to entrance from the shoulders, has been eliminated. . . . By shoulder treatment we believe that a wider travel path

ASPHALTIC CONCRETE ROAD IN RHODE ISLAND WIDENED WITH BITUMINOUS SHOULDERS.

has been furnished, that constant maintenance of the shoulders due to storm washing largely has been eliminated and that a narrow road has been increased to a reasonable width for modern two-way traffic at low cost.

### COSTS OF WIDENING IN CONNECTICUT.

(a) Widening with penetration macadam, \$1.00 to \$1.25 per sq. yd.
(b) Gravel or stone shoulders surface treated, 20c to 25c per sq. yd.
(c) Natural soil shoulders, oil treated, 9c to 13c per sq. yd.

### THE METHODS ADOPTED IN INDIANA.

Mr. A. H. Hinkle, state superintendent of maintenance in Indiana, reports as follows: When an old road is resurfaced with asphalt, the base first is widened with stone, gravel or slag to fit the new width desired. This widening is done sometimes on long stretches of road and other times on short lengths here and there where the old pavement is too narrow and on curves where widening is a safety measure. There are approximately 835 miles which thus have been reconstructed with various types of bituminous wearing surfaces. An outstanding example is the widening of a section of the Dunes Highway (U. S. Route No. 12) on the south shore of Lake Michigan, where four-foot "retread" shoulders on a slag base were placed adjacent to a twenty-foot concrete pavement. This additional width has prevented many accidents. It makes traffic feel much safer and it was done quickly and at reasonable cost.

### WIDENING PRACTICE IN MASSACHUSETTS.

Mr. G. H. Delano, maintenance engineer of Massachusetts, reports:

ASPHALT MACADAM ROAD IN RHODE ISLAND WIDENED WITH SURFACE TREATED MACADAM SHOULDERS.

State roads have been widened by using penetration macadam shoulders and by oiling natural soil shoulders. Such methods materially reduce maintenance costs and increase the safety of the roadway.

## SHOULDER TREATMENT IN RHODE ISLAND.

Mr. Daniel Soule, maintenance engineer of Rhode Island, a member of this committee, reports as follows: "Shoulder treatment started with the increase in speed of the automobiles, recreating the dust nuisance of years before. Immediately after treating the shoulders with the light oils, the public began to use the shoulders for parking spaces. The material was not strong enough or stable enough for that use and we started to make something better. We, in Rhode Island, do not design or build these shoulders as additional travel surface. We believe the travel surface should be built to correspond with the original surface when traffic demands it but we do build a shoulder where traffic may turn out to avoid accidents or where the cars may park for repairs.

CONCRETE ROAD, NORTH OF NEW HAVEN, CONN., WIDENED WITH BITUMINOUS TREATED GRAVEL SHOULDERS.

"Our general practice has been to excavate any objectionable material for a sufficient width to accommodate parking and for a depth that may be replaced with a weight-bearing gravel that will take the surface treatment. The asphaltic treatment on top seems to hold with lighter and less frequent maintenance over a period of years. We do not know how long a period because we haven't any shoulders that have outlived their time yet. At some places this shoulder hardening is carried on as part of a program for future widening. If the shoulders are exceptionally soft, at times we have gone as far as to excavate from fifteen to eighteen inches and fill in with stone or some other suitable material which would bring that road into condition where, in the future, a widened pavement might be put on a proper foundation as it was needed.

"Now, our justification for this, primarily, was service. We believed that the service to the public justified the extent to which we went in hardening and maintaining these shoulders. However, after doing it we now find that the repair bills for maintenance on the metal surface are very materially reduced. In fact, on a bituminous hard surfaced road, the surface maintenance is reduced nearly two-thirds as soon as the shoulder is hardened and properly kept up. The shoulder maintenance, after hardening, is reduced to about two-thirds the cost of maintaining the natural shoulder, while the maintenance of our surface drainage structures is cut almost in half by stabilizing the shoulder and keeping the wash out of those structures. While the township authorities believe that costs of shoulder treatments are beyond their budget allowance, it is my opinion that all roads of any importance should receive bituminous treatment, which would soon save the extra expense involved through actually reduced maintenance expenditures."

### CONCLUSIONS DRAWN FROM REPORTS.

(1) Widening old pavements with asphaltic types essentially is sound and, in view of the saving in cost, together with increased service to the public, should be extended as standard practice. Destruction of an old pavement in order to construct an entirely new one is practically always an unwarranted waste of public funds and can be justified only when an entire relocation in grade and alignment is imperative.

(2) Widening can be carried on gradually as funds are available, either on one side or both, and roads formerly having poor alignment can be straightened remarkably by placing all widening on the inside of the curves.

(3) Road surfaces with high crowns and no super-elevation, can be improved in both respects with widened areas, so constructed as to conform to modern design and at the same time all the previous investment can be conserved.

(4) Many narrow pavements now showing signs of failure because of concentration of traffic can be carried along for many years with entire satisfaction by widening the berms with the asphaltic types, thus waterproofing the surface at the edge and preventing saturation of subgrade.

(5) Asphaltic treatments on gravel, stone or natural soil shoulders markedly reduce maintenance, increase the safety of the roadway and permit lateral dispersion of traffic over the entire pavement width. The surface is waterproofed so that moisture cannot enter at the edge of the pavement and soften the subgrade.

(6) Since widening operations with the asphaltic types can be carried on in progressive stages, they lend themselves to every degree of traffic and size of the pocketbook. Crushed stone, gravel or slag can be placed on the shoulders as rapidly as funds permit, in layers of any depth, can receive compaction under traffic and can be added to as conditions make necessary until a thorough consolidation obtains. The final wearing surface then can be achieved either by surface treatment, "mixed-in-place" or plant-mix methods without delay to traffic and at minimum cost.

(7) Accidents on highways largely can be reduced by having stability

TABLE 1.

| STATE | *Widening and Retaining Original Surface* | *Adding New Base Either Side and New Surface Over Whole* | *Shoulder Stabilization* |
|---|---|---|---|
| ARKANSAS | Planning on several projects for penetration macadam. | | |
| CALIFORNIA | | Very extensive program. Widening old concrete roads with concrete base and placing asphaltic concrete wearing course. | Using bituminous macadam shoulders, premixed oil and gravel, and oil treatment of natural soil. Very satisfactory. |
| CONNECTICUT | Widened old macadam roads with asphalt penetration macadam, 16 feet to 20 feet. | Old concrete widened with concrete and the whole resurfaced with asphaltic concrete. | Treatment of sand and gravel shoulders with bituminous materials, including asphaltic oils, very successful. Increasing in use every year. |
| GEORGIA | Widening several concrete roads with limerock and surface treating with asphalt. | | In mountain sections shoulders replaced with crushed local stone thoroughly compacted and rolled. Asphalt surface treatments reduce erosion and maintenance most satisfactorily. |
| INDIANA | Concrete widened with retread. Example, Dunes Highway, U. S. 12, Gary to Michigan City, 26 miles widened 4 feet each side, 8-inch slag base and 2½-inch asphalt retread top. Successful under heavy traffic. Maintenance costs reduced. | Many miles of old stone roads widened and strengthened. Covered with penetration macadam or retread wearing course. | |

PAGE 2.

| STATE | *Widening and Retaining Original Surface* | *Adding New Base Either Side and New Surface Over Whole* | *Shoulder Stabilization* |
|---|---|---|---|
| IOWA | | | Has experimented with asphalt mixes for sloping gutters. |
| KENTUCKY | Large mileage of old stone roads widened and reshaped, then surface treated. Example, U. S. 60, Lexington west, widened 15 feet to 21 feet by placing 9 inches of macadam on each side. Very satisfactory under heavy traffic. | Old stone roads widened and covered with retread tops. | Widening by placing crushed stone on earth shoulders and compacting under traffic until thoroughly stabilized, followed by surface treatment. Later widened width can receive new top course as traffic warrants. |
| MASSACHUSETTS | Old macadam pavements widened 3 feet each side with penetration macadam. Some pavements, concrete and bituminous macadam 18 feet, widened to 30 feet with asphaltic macadam and asphaltic concrete. | Approximately 100 miles of state roads and 120 miles state supervised town roads reconstructed and widened annually with asphalt. | Treatment of sand and gravel shoulders with asphaltic oils. Reduces wear and lowers maintenance costs. Uses asphaltic concrete on Cape Cod for paving gutters and runoff ditches. |
| MICHIGAN | Eighteen foot asphaltic concrete on concrete base, widened 9 feet on each side with same type. | Old macadam widened with 2 feet concrete, then whole surface covered with asphaltic concrete; service record 8 years. Old macadam widened with 10-foot concrete and sheet asphalt placed over whole surface.<br>Gravel roads widened and covered with asphaltic concrete (state plant operation). | |
| MINNESOTA | Trunk Highways No. 10 and No. 63 out of Minneapolis, old concrete roads, 16 to 18 feet, widened to 27 feet with concrete and asphaltic concrete placed over whole. | | Experimenting with oiled shoulders. |

PAGE 3.

| STATE | *Widening and Retaining Original Surface* | *Adding New Base Either Side and New Surface Over Whole* | *Shoulder Stabilization* |
|---|---|---|---|
| MISSOURI | Plans widening 18-foot concrete to 21 feet by penetration shoulders of crushed stone and asphalt. | | Narrow concrete roads with 10-foot earth shoulder. This shoulder treated with asphaltic oil, one gallon per sq. yd. Good results. With blow-sand subgrade use 10-foot gravel shoulder, treated with heavy asphaltic oil and mixed in place. Cost $500 to $800 per mile. Results good. To be extended. |
| NEW JERSEY | Eighteen-foot concrete widened with penetration macadam shoulders, 7½ feet each side. Asphaltic concrete widened by placing macadam base on shoulders and surfacing with asphaltic concrete. | Old Telford base widened with macadam and whole surfaced with sheet asphalt, asphaltic concrete and asphaltic macadam. Old type high crown, widened with macadam base and surfaced with asphaltic concrete, overlapping old pavement to produce flat crown. | Gravel and sand shoulders adjacent to pavement treated with asphaltic oil. Plan to extend work with similar treatments in 1931, using new methods. |
| NORTH CAROLINA | Ten-foot sand asphalt widened 3 feet each side, same type. Original construction 1922, 3-inch base, 1½-inch top, 18-foot asphaltic concrete on concrete base, widened to 30 feet with 5-inch concrete base and sheet asphalt top. | Ten-foot penetration macadam widened with concrete at sides to 30 feet. Sheet asphalt surface over all. | |
| OKLAHOMA | | | Using asphaltic road oil and gravel, mixed in place, for shoulders. |

PAGE 4.

| STATE | Widening and Retaining Original Surface | Adding New Base Either Side and New Surface Over Whole | Shoulder Stabilization |
|---|---|---|---|
| OHIO | Building up macadam shoulders on old high crown macadam pavements, then surface treating over all. | | |
| PENNSYLVANIA | | | Places penetration macadam shoulders for greater width. |
| SOUTH CAROLINA | | | Surface treatment of gravel shoulders adjacent to concrete roads with asphalt emulsion. Treatment of top soil shoulders with tar prime and hot asphalt seal. Plans to extend this method. |
| UTAH | | Nine-foot concrete widened to 18 feet with "black base," then whole width covered with asphaltic concrete (1921). 16-foot concrete widened with 2-foot concrete and then whole width covered with bitulithic and asphaltic concrete (1925). Results good. | |
| VIRGINIA | Widening and super-elevating old macadam, using penetration macadam. | U. S. Route No. 1, south of Washington, D. C. Old 18-foot concrete road widened with concrete shoulders, then all resurfaced with sheet asphalt.<br>State Route No. 408, old concrete widened to 30 feet and covered with sheet asphalt. | Surface treatment of soil shoulders adjacent to concrete, south of Petersburg. |

PAGE 5.

| STATE | *Widening and Retaining Original Surface* | *Adding New Base Either Side and New Surface Over Whole* | *Shoulder Stabilization* |
|---|---|---|---|
| **WEST VIRGINIA** | Nine-foot concrete on U. S. Route No. 50, very crooked alignment. Widened and straightened, using varying shoulder widths, with asphaltic penetration macadam. | Old concrete and brick roads widened with macadam base and concrete and resurfaced with asphaltic concrete and cold premix types. | |
| **WYOMING** | | Old concrete widened with concrete shoulders and whole surfaced with 2-inch asphaltic concrete. | |

of the berms, so that vehicles can turn off the pavement completely whenever necessary, without fear of being mired.

(8) Asphaltic treatment of the shoulders not only achieves all purposes outlined above but also prevents erosion, thereby reducing the maintenance of the structures through the elimination of the wash which otherwise causes stoppage during a heavy rainfall. In this respect alone the cost of treatments is justified.

CHAIRMAN LYON: Gentlemen, the report read by Mr. Gray has been a very valuable one and we would like to have some discussion on it. The other members of the committee, I understand, are not present. This paper is too valuable, it seems to me, to pass up without some remarks from men who have had experience along this line. If there is no further discussion on this last paper, then we will call on Major F. M. Davison, maintenance engineer for the District of Columbia Highway Department, Washington, D. C., for the "Survey Report of the Committee on Maintenance Methods."

# Survey Report of the Committee on Maintenance Methods

### By Major F. M. Davison, Washington, D. C.

*Chairman*

I want to preface my remarks by expressing my appreciation of the

AN OLD MACADAM ROAD COMPLETED BY WIDENING, CONSTRUCTING CURB AND GUTTERS AND COVERING WITH BITUMINOUS CONCRETE.

support we have had in compiling this report and the spirit in which the data asked for in the questionnaire was sent to us. At times I have had four or five questionnaires on my desk and I have wondered how I was going to wade through them and still do my own work. Every time I finished with one on my desk it seemed that another one came in. The cooperation we had in the answers to the questions propounded exceeded anything I thought would be accorded us.

## SECTION I.

No doubt, during the past year, you have been the recipient of one or more questionnaires which were sent out by various organizations in quest of information relative to what you are doing, how much you are doing and how you are doing it. If such is the case, stop to consider for just a moment the work involved in the analysis of the numerous answers that have been received from this one particular questionnaire on maintenance. There are many engineers who cast aside carelessly a questionnaire, or else in making reply do not convey sufficient data for tabulation of the facts. It was most pleasing to observe that in the maintenance questionnaire the answers received in the majority of cases were extremely thorough and gave sufficient data so that we feel we really know what is going on.

Rolling and Testing with Straight-Edge the Finished Sheet Asphalt Surface, Placed as a Wearing Course over Old Concrete on the Alexandria, Va., Road South of Washington, D. C.

### Uniformity in Keeping Maintenance Records.

The first question asked that the various state and county engineers should give available statistical data readily at hand on the maintenance of the various types of pavement coming under their jurisdiction and, if they had such a thing, the accurate cost of maintenance per square yard per year and, in case they did not keep any accurate data, their estimate of the maintenance cost especially with reference to the asphaltic type streets. It is apparent from a majority of answers from the state highway department, as well as those from county departments, that most maintenance records are kept on a per-mile basis and that often the maintenance of the roadway is given in its entirety; that is, to say, there is no differentiation between money expended for the maintenance of the travelled surface, the shoulders, drainage and repairs to structures. It further is apparent that most of this cost data, kept on a per-mile basis, includes many major improvements which properly should not be classed under the head of maintenance. Consequently any direct comparison of the various costs submitted by the highway departments, in our opinion, would not convey any sound and useful information. Consequently, we are quoting very few figures. In the tabulation of the reports, Massachusetts was found to be one of the states with the longest record on maintenance costs and, in truly methodical New England fashion, that state has kept a fairly accurate square-yard cost. The Massachusetts records show a steady decrease in the maintenance of the asphaltic type surfaces of modern type construction. Quoting briefly from the Massachusetts report, we find square-yard maintenance as follows:

| | 1927 | 1928 | 1929 |
|---|---|---|---|
| Asphaltic bituminous macadam | .026 | .016 | .014 |
| Asphaltic concrete | .013 | .012 | .009 |

The Massachusetts method of accounting shows the maintenance cost per mile on a percentage basis. In other words, it shows a certain per cent of the total expended for surface, another for curb and gutter and other percentages for the miscellaneous items entering into maintenance. It is the recommendation of this committee that uniformity in the methods of keeping maintenance records by the states would be beneficial not only to the states themselves but for general public information. The system employed by Massachusetts is worthy of study by any state which is not satisfied with its present statistical data.

### Maintenance Handled by Contract.

The next question concerned the extent to which contract methods of doing maintenance work have been employed. From the replies received, it was noted that no state or county does its maintenance work in its entirety under a contract. However, there is a distinct trend toward the placing of such items under contract as lend themselves readily to the contract form. These items include the distribution of asphaltic materials, the purchase of premixed asphaltic concrete and, in a number of cases, the contracting of complete surface treatment programs.

The committee believes that, by careful budgeting and scheduling of the work well in advance, a great deal can be done toward increasing the number of items which it is possible to place under contract. The advantages to be derived from such contract work not only include reduction in cost but, even more important, such a method would make it possible for the major maintenance items to be completed prior to the opening of the heavy summer traffic. We believe that the greatest attention should be given to that form of maintenance which will provide for the maximum use of the road with a minimum interference to traffic. While the state and county systems have not yet employed this plan of contracting maintenance to any large extent many of our biggest cities have tried it and have found it to be exceptionally satisfactory.

STREET MAINTENANCE IN WASHINGTON, D. C. A NEW PATCH MADE WITH THE "D. C. MIX" OF ASPHALTIC CONCRETE BEFORE THE FINAL ROLLING.

## MAINTENANCE OF TOP SOIL AND SAND-CLAY ROADS.

We next endeavored to ascertain from the various states and counties to what extent they were maintaining the natural soil or sand-clay surfaces and similar types of roads by the use of road oil or asphalt and what materials and equipment they were using. It is apparent that in the majority of states, the treatment of soil and sand-clay roads is still in its infancy. However, many southern states, including Georgia, Florida, North Carolina, South Carolina and Virginia, have large mileages of surface treated top soil roads which are carrying successfully a traffic as great as 2,000 vehicles per day. There are a great many miles of this type of surface more than three years of age upon which traffic has averaged more than 1,000 vehicles per day. These roads still are in excellent shape. This, we feel, is indicative of the results that can be obtained by other states which have not yet entered this field.

Minnesota has a natural gumbo soil and has had marked success in the treatment of top soil roads with slow curing asphaltic oils. A light layer of sandy gravel is used for a cover coat. The state has constructed several hundred miles of this type and these roads are successfully carrying a traffic of three hundred to eight hundred vehicles per day, throughout all the seasons of the year. A great deal of interest is evident in the various methods of treating natural soil and sand-clay roads, because every state is confronted with the problem of extending its mileage to include many such surfaces for carrying medium and light traffic. Large areas in many states have very little satisfactory road building material locally available and, if they are to have any truly inexpensive treatment of natural soil roads, methods and materials must be carefully considered, with a minimum importation of aggregates and the greatest possible use of local materials. In these various surface treatments we see the greatest promise for light traffic, low cost roads.

### Advantages of Low Cost Roads to Counties.

Nebraska has just finished an experimental section nine miles in length, built in cooperation with the United States Bureau of Public Roads and located in its sand hill area. The local material used is a very fine grade of sand almost entirely lacking in any cementitious qualities. While the work is of such recent completion as not to warrant definite conclusions, the state authorities indicate that the oil treatment of such sandy subgrades will be carried further and the success of this type of road apparently is assured.

The committee feels that such types of treatment should be attractive especially to those states and counties which are not in a position to spend a great deal of money per mile on their roads, and yet where traffic is developing so fast that they must do something. We recommend that the states interested get in touch with the State Highway Department of

Asphalt Street Maintenance in Washington, D. C. Showing Burner in Operation and Removal of Thin Layer of the Surface Prior to Placing New Material.

Nebraska and the United States Bureau of Public Roads, from whom we are sure much valuable information and help can be secured.

The successful surface treatment of gravel roads with road oil and asphalt is of interest to all engineers, in as much as the materials and methods employed now are in a state of continual improvement. The surface treatment of macadam roads is not a difficult proposition, nor is it hard to determine what type of material to use in order to secure a successful surface treatment on a macadam road. From the reports received, we find that almost all of the states which have any appreciable mileage either of macadam or gravel roads are using asphaltic surface treatment as their major maintenance method. Many of the states now are using cut-back asphalt instead of the former hot treatments and are securing splendid results. Excellent results also are being obtained by the use of asphalt emulsions of the quick-breaking type. The successful surface treatment of gravel roads falls into two distinct groups, the first group including cementitious gravel, which may be thoroughly consolidated and then swept clean prior to the application of asphalt, and the second, made up of those loose, sandy gravels which must be consolidated by a priming application prior to the distribution of the seal coat. Nearly one-third of the total surfaced mileage of the state system and over one-half that of the county highway systems, in fact something over 93,000 miles and 275,000 miles respectively, comes under the heading of gravel, chert and similar types of road surface. The proper surface treatment of this *large mileage* would *markedly improve* the serviceability of the various state and county highway systems. It must be apparent that for many years to come, such types will have to be con-

Asphalt Street Maintenance in Washington, D. C. Another View of the Burner, with the Softened Material Raked Off Prior to Patching.

structed and maintained. *Too much emphasis cannot be placed upon the development of the best practices in asphaltic surface treatments* because of the much lower maintenance cost on treated surfaces as compared with the ones that are untreated.

### LOSS OF SURFACING ON UNTREATED GRAVEL.

In connection with gravel roads, from the information received from the various state and county highway departments, we note that there is a loss of from one-half inch to one inch in depth of gravel annually from an untreated gravel road and the cost of this gravel replacement frequently is in excess of the entire cost of an asphaltic surface treatment. The possible economies obtained by sealing a gravel road with an asphaltic material, the elimination of the dust nuisance and the permanently smooth and improved riding surface obtained also will result in a direct reduction in the cost of motor vehicle operation.

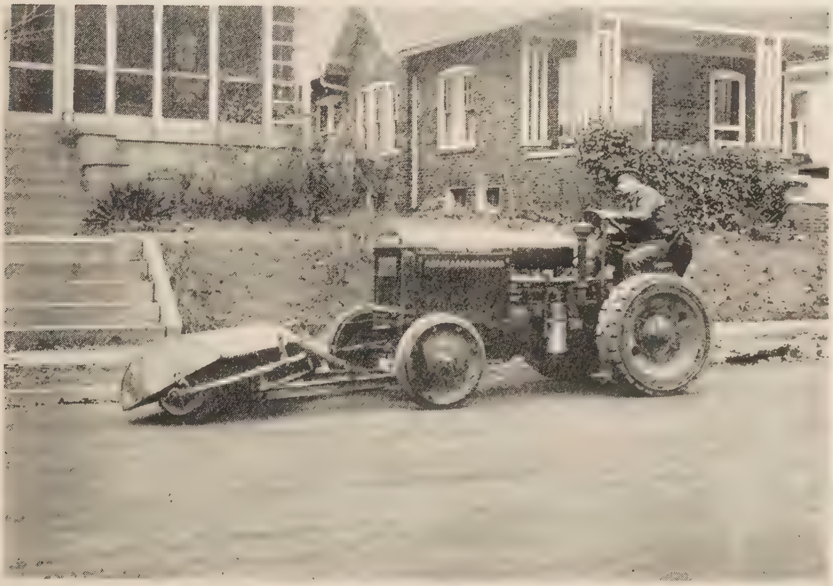
In the treatment of the highly cementitious gravel roads the best practice seems to be in making several applications of asphalt of small amounts rather than a single placement of the same total gallonage at one shot. By following this method any small surface areas which are not entirely covered by the first application are sealed off in the later applications. Excellent results have been secured both with and without a prime coat. The committee, however, after its study of the question, recommends the use of a light prime asphalt even on the highly cementitious gravel roads in order that the fine particles may be consolidated thoroughly to a depth of one-half an inch to an inch below the surface, and also because a surface that is properly primed seems to have a closer bond with the asphalt seal coat than an unprimed surface. We note that there is a distinct trend toward the use of cut-back asphalt in the surface treatment of gravel roads.

In the treatment of loose, sandy, gravel roads, it first is essential to consolidate the surface to a depth of from one to two inches, using an asphaltic oil of 60 per cent to 70 per cent asphalt or a cut-back primer, and, after the first application, which will approximate .4 of a gallon to the square yard, the entire surface should be thoroughly disced and manipulated with a grader and then smoothed and rolled. After the surface has been consolidated thoroughly by this priming and mixing, the subsequent treatments either of hot asphalt, cut-back asphalt or heavy oil, may follow. It is advisable to allow such time between the application of the prime coat and the final application of the seal coat as will permit the volatile matter in the oil prime to evaporate. This interval varies from two days to several weeks, according to conditions. The practice varies in the different states.

### RETREAD AND MIXED-IN-PLACE METHODS.

With their large mileage of gravel roads the counties would develop much more successful surface treatments we believe, and that, too, on a more thorough and economic basis, if there were a little more consultation between the state and county highway engineers prior to planning the surface treatment programs.

The questionnaire included a request for information from the various state and county highway departments as to what extent they had been using the "mixed-in-place" or asphaltic "retread" treatment for the reclamation of worn out macadam roads and the improvement of gravel roads either treated or untreated. From the reports we find that Indiana leads with approximately 300 miles of this type of reconstruction. Ohio has approximately 100 miles, while Tennessee is laying from 300 to 400 miles per year of a type that is intermediate between surface treatment and standard "retread." The material to be used in constructing either one of these types of roads, we believe, should be a cut-back asphalt, cut back to permit sufficient time between the application and the final set-up, after such manipulation and mixing as may be necessary. However, the question of just how much solvent should be used, in order that the material be of the right consistency to permit ready mixing and yet not approach a sloppy stage, is one upon which considerable work is yet to be done. Almost all of the big asphalt producers have developed a particular brand of asphalt for this use and have utilized their article with marked success.



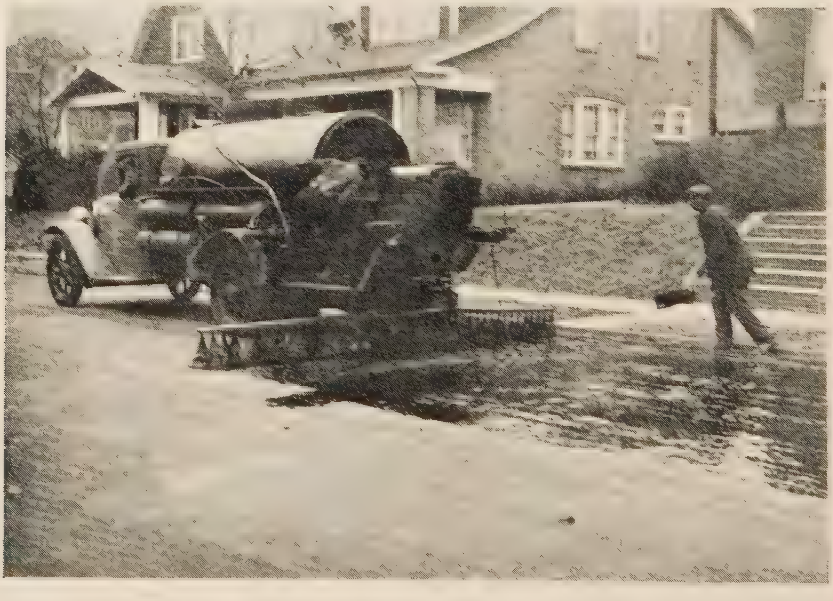
Placing a Non-Skid Asphalt Surface Treatment in Washington, D. C. The First Operation. A Tractor Push-Broom at Work. Note that it is in Full View of the Operator.

The "mixed-in-place" method seems to be extremely popular with the various states and counties that so far have used it and it is the committee's recommendation that in stage construction and the development of state and county highways, this type of pavement has a distinct place and will continue to grow in popularity.

In endeavoring to ascertain the various methods and equipment used in the maintenance of asphalt macadam roads, we find from the questionnaire that where minor maintenance is undertaken, it almost always is done by employing small asphalt kettles, some using a cold material and some requiring a hot one, with small trucks carrying chips and hand tampers. Where the maintenance is of a major character surface treatment or seal coating, either with hot or cold asphalt from power distributors, is employed. There are a few basic facts in connection with seal coating and surface treatment upon which the committee wishes to lay special stress. We believe first, that the amount of asphalt should be the smallest possible quantity that will hold the cover material. We believe also that the asphalt content should be of fairly low penetration. Just what the specific viscosity should be will vary according to the locality but in the eastern section of the United States the standard specific viscosity Engler seems to be from 18 to 25.

### Use of Cold Patch Materials.

Secondly, we believe that the character of the cover material should be studied carefully. Gravel, limestone chips, traprock and slag all have proven to be excellent cover materials. We believe that the outstanding size of aggregate to use for surface treatment is from 100 per cent passing $^{3}/_{4}$ inch to 5 per cent passing $^{3}/_{8}$ inch. We believe that the use of this larger sized cover material, especially where it is possible to employ the use of a roller for setting, will bring about results superior to those obtained by using a smaller sized aggregate. We also are of the opinion that there have been far more failures of pavement due to pushes, bituminous rolls and shoving from an over-application of bitumen and the use of too small a cover material than from any other causes.



Placing a Non-Skid Asphalt Surface Treatment in Washington, D. C. The Cut-Back Asphalt is Applied at the Rate of Four-Tenths of a Gallon per Square Yard by Means of a Pressure Distributor.

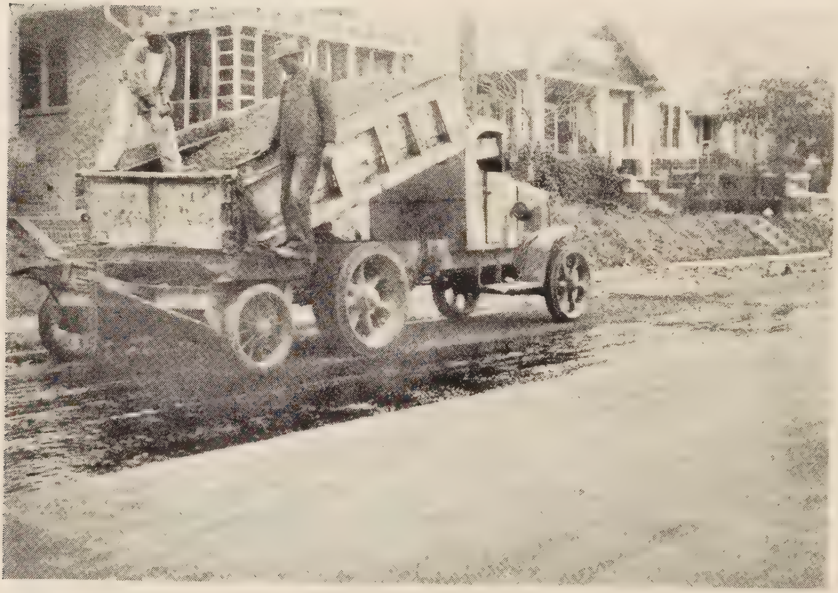
The canvas of the various state and county highway departments relative to the extent of their use of cold patch materials, both of the premixed bituminous concrete variety and the liquid asphalt type, brings to light the fact that very few of the states use a cold premixed bituminous type of material for patching and that the majority are using the liquid cold patch, endeavoring to accomplish their minor patch work along a semi-penetration type method and securing excellent results. The equipment used seems universally to be hand pots and kettles. Virginia, Missouri, Ohio and Oklahoma are among the largest users of liquid cold patch, with Louisiana leading the field in the use of pre-mixed bituminous patch material.

The use of an asphaltic seal coat for making both major and minor repairs to asphalt macadam roads seems to be somewhat limited. However, we find that most of the states are using a seal coat over all "mixed-in-place" and asphaltic "retread" jobs and many of them report that their major maintenance on bituminous concrete roads is accomplished when needed by the use of an asphaltic seal coat. To differentiate between a seal coat and surface treatment is practically impossible. In none of the states or counties canvassed have we found the use of the surface heater employed in the maintenance of any type of asphalt street. However, we believe that the use of heaters or burners may be employed very profitably and economically in removing bituminous rolls. This method of repair at present generally is confined to the big cities.

## Methods of Filling Cracks and Joints.

Only one state appears to be using a reclamation method on bituminous roads along the line of softening the old surface with a light oil, allowing the road to be closed for sufficient time for the applied oil to cut back or soften the old bituminous surface and then reshaping the road by blading or honing. This method has produced excellent results and we believe it should be investigated by state and county highway departments which have any appreciable mileage of worn and rough macadam roads. The cost of this type of maintenance has more than justified the results obtained.

In trying to ascertain the type of asphaltic materials used for the maintenance of cracks and joints in Portland cement concrete as well as the asphaltic materials employed in patching broken areas in cement concrete, brick and block pavements, we encountered the most diversified opinions. Fully half the states and counties reporting are using an asphaltic crack or joint filler with a penetration of from 85 to 100. Some of the states are specifying that this asphaltic crack-filler shall contain a fine mineral filler. Other states use straight asphalt without the mineral filler. This subject is so wide open at the present moment and there is such difference of opinion concerning just what penetration or what type of material is best to use that the committee simply reports the result of the canvas and does not present or recommend any particular penetration since the states have varying temperatures and climatic conditions. On the whole, it is noticed that the filling of cracks and joints in Portland cement concrete is being accomplished much more carefully than formerly was the case. Most of the highway departments are employing compressed air for cleaning the cracks and joints prior to filling and an effort is being made to use just enough bitumen to fill the crack, with no attempt to surface treat the surrounding area. In patching broken areas in cement concrete, brick and block pavements



Placing a Non-Skid Asphalt Surface Treatment in Washington, D. C. After the Asphalt has been Applied Slag Chips are Spread with Mechanical Equipment.

most of the states report using a number of cold premixed asphaltic materials, all with varying degrees of success.

## Special Methods Developed for Maintenance.

In answer to the question as to whether there was any special feature in the way of equipment or methods employed in the maintenance of the various type pavements that would necessitate a special study by the committee, or a personal inspection trip, many very interesting answers were received. Minnesota, with its treatment of gumbo soil by using a road oil, presents a very interesting study in the treatment of natural soil roads. Virginia reports the development of a special road blower, for use with surface treatment, that produces a distinct improvement in this type of work. South Carolina reports the development of a non-skid treatment on asphaltic concrete roads which consists of the application of one-tenth of a gallon per square yard of kerosene. This is allowed to penetrate or cut back the fat surface, after which new chips are rolled into the road. The results obtained by this method are worthy of study by states and counties which have similar problems to overcome. Indiana has developed its special asphaltic "retread" to a degree where results really are exceptional and Ohio, with its large mileage of traffic-bound macadam roads, has designed a multiple-blade drag for maintenance which accomplishes excellent results. For the particular states interested in these various types we believe that a study of the procedure in the above named states will be of material aid in future maintenance operations. Practically all of the states and counties reported some outstanding section of asphaltic road which was particularly worthy of note, both as to low original cost and continued low maintenance cost.

### DIFFICULTIES ENCOUNTERED IN MAINTENANCE.

We have saved for the last question presented, the one that is most difficult to answer. We requested the various states and counties to state what they considered their most difficult problem in connection with maintenance of roads and street surfaces. From the reports received, we are of the opinion that there are so many difficulties in connection with maintenance work that to single out any one of them as the most difficult is asking, almost, the impossible. With maintenance of the county systems the chief difficulty reported seemed to be that of securing adequate finances with which to do the large amount of work required. With the states this financial question, while of considerable importance, appeared to be less difficult. The particular difficulties reported are listed briefly for your information, so that you can see that other states and counties have troubles equal to your own. The State of Wisconsin is troubled considerably with frost action in breaking up the surfaces of its roads. Louisiana seems to feel that the cost of using cold premixed materials may be reduced and the State of Virginia's outstanding source of worry seems to be difficult drainage. Indiana reports considerable trouble in accommodating traffic while maintenance work is going on and Missouri is experimenting with new asphalt fillers for concrete. Minnesota is developing an inexpensive treatment for the stabilization of gravel roads that will carry heavy traffic and Ohio is working out a way to eliminate the dust from her traffic-bound macadam roads. New Jersey

PLACING A NON-SKID ASPHALT SURFACE TREATMENT IN WASHINGTON, D. C. HAND SPOTTING WITH SLAG TO COVER THE FEW PLACES THAT ARE NOT EVENLY COVERED BY THE SPREADER.

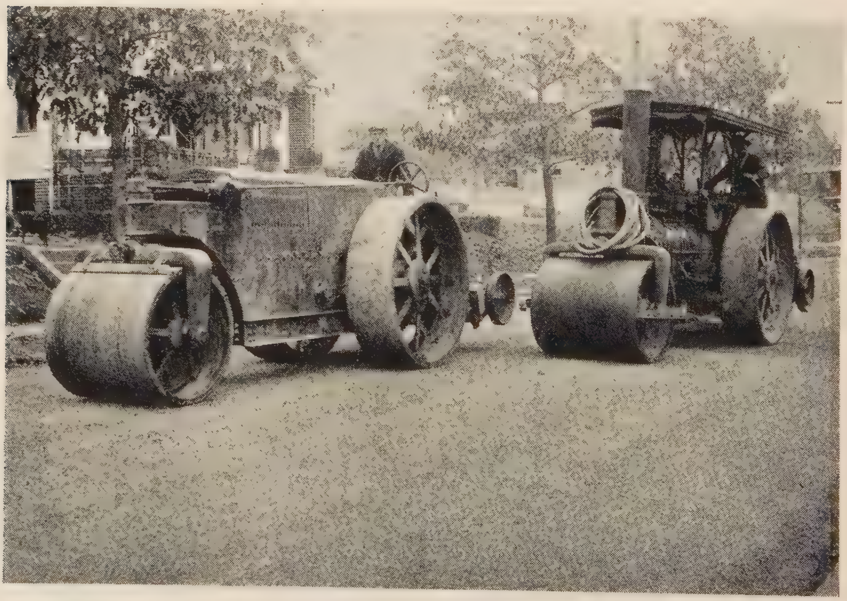
cities seem particularly concerned in developing even smoother sheet asphalt streets, while Massachusetts is concerned most with the widening of macadam roads to prevent ravelling.

The similarity of the answers received and the problems encountered in the maintenance of both state and county highways have been such that the committee, for the purpose of brevity, has reported the canvas under a single heading. The problems of the big cities along the maintenance line also are different in the main and are taken up separately.

### Maintenance Costs in the Large Cities.

In the analysis of the questionnaires received from such cities as San Francisco, Denver, Charleston, Los Angeles, New York, Washington, Philadelphia and Detroit, it was noted that the majority show a large yardage of sheet asphalt pavements maintained at an average annual cost per yard per year of $.04705, including reconstruction. Costs as reported for the maintenance of macadam pavements by means of the application of asphaltic materials through a surface treatment method, exclusive of major patching and reclamation work, approximate an average of $.0655 per square yard per year. In the reports of maintenance cost covering *untreated gravel roads,* while the mileage is small, the range seems to be from 16 cents to 21 cents per square yard per year, depending upon the traffic.

Many of the larger cities are employing the contract method in its entirety for their maintenance work, especially in connection with the repair of sheet asphalt streets and utility cuts. The application of



Placing a Non-Skid Asphalt Surface Treatment in Washington, D. C. Rolling—and Plenty of it. These Ten-Ton Rollers Go Over each Square Yard at Least Ten Times. Note Ample Cover Material—Ten Pounds for each One-Tenth of a Gallon, or 35 Pounds per Square Yard for each .35 of a Gallon of Asphalt. Less than Two Pounds per Square Yard Whip Off.

asphaltic surface treatments to macadam roads in the large cities seems to be done almost entirely by contract and employment of the surface-heater method for maintaining sheet asphalt streets also is almost entirely done by the contract method. Some of the largest cities, however, are doing the work with their own forces. We believe that as time goes on almost all of the big cities eventually will come to contract methods of doing their work. The cities which report using contract methods at the present time are very enthusiastic and report exceptionally satisfactory and economical work.

Almost all of the larger cities doing any maintenance work at all on natural soil roads report the use of a dust-laying oil, known under the government master specifications as "OC-2". No attempt seems to have been made to develop any lasting surface in the cities with this type of material, but it has proven very satisfactory in applications of from one-third to one-half of a gallon per square yard as a dust palliative. This use of a light dust-laying oil seems to be much more economical and lasting than the employment of sprinkling wagons using water.

In those cities reporting, which have any considerable mileage of macadam and similar type pavements, we find that they are doing most of the maintenance work, exclusive of pot hole patching, with asphaltic surface treatments. The asphaltic materials used vary considerably, as do also the size of the cover material used, the gallonage applied to the square yard and the methods employed. However, we notice that there is a distinct trend toward the employment of a cut-back asphalt of a fairly heavy grade and there also seems to be a leaning toward the use of a cover material, either of gravel, stone chips or blast-furnace slag of a size from three-quarters of an inch to three-eighths of an inch, rather than the smaller sizes formerly employed. The survey shows distinctly that almost all of such work is done under contract by the larger cities rather than by force account.

## MAINTENANCE IN OUTLYING CITY DISTRICTS.

Only very recently have the larger cities paid any particular attention, aside from dragging or blading, to the maintenance of their gravel streets, inasmuch as these streets formerly were in the outlying sections and did not demand any appreciable maintenance. However, these outlying sections now are well built up and consequently require attention as traffic increases and the consequent maintenance cost mounts. The committee feels that the surface treatment of gravel roads was discussed in sufficient detail in the analysis of state and county highway methods and that it is not necessary to dwell further upon it here. The same situation applies to the surface treatment of macadam roads.

The use of the "mixed-in-place" or asphalt "retread" type of maintenance in the cities appears to be popular particularly in the building of park systems, the improvement of suburban through roads and streets where traffic is fairly heavy and the demand is for a serviceable and easy riding road at a minimum cost. It is noticeable that many of the larger park systems are employing this asphalt "retread" over the former old macadam, thereby salvaging the basic material in these old roads. The reports indicate that whenever this type of maintenance has been used in the cities results have been very successful. In the repair of this type of

Newly Completed Non-Skid Asphalt Surface Treatment in Washington, D. C. The Whipped-Off Cover Material at the Side is Swept up and Used Elsewhere.

surface we find that cut-back asphalt of a heavy grade and asphalt emulsions are being used.

In line with the state and county highway departments, we find that the larger cities are using asphaltic seal coats or surface treatments for the major maintenance of their bituminous macadam roads, the minor maintenance being carried on by means of hand patching. We find also, in analyzing the reports, that both hot and cold asphalts, as well as asphalt emulsions, are being used with marked success. We also note that the trend in the cities, as in the states and counties, seems to be toward a very light treatment, made at intervals, with a larger size of covering material, in place of a heavy application of bituminous material.

At direct variance with the state and county highway departments, we find that the cities are using a cold premixed asphaltic type of bituminous concrete for their major and minor patch work and that this asphaltic bituminous concrete is both purchased under contract from a central manufacturer and made up by local forces. The material, in addition to being used in the patching of macadam roads, has been used with marked success for the patching of broken areas in Portland cement concrete roads and for the reshaping of old macadam roads. The reports vary, with cities using as much as 16,000 tons annually and other cities of equal size using comparatively little. Quite a few of the cities reporting are still using a liquid cold patch and making either direct or inverted penetration patches with excellent results. Considering the traffic in the large cities, it is the opinion and recommendation of the committee that the use of a cold-mixed asphaltic bituminous concrete is preferable to the liquid cold patch. Use of a seal coat made with an asphaltic cut-back material seems to be quite prevalent in the maintenance of old bituminous concrete roads. As this subject also has been discussed before, it will not be entered into here.

### LARGE CITIES USE SURFACE HEATER METHOD.

The reports from San Francisco, Philadelphia, Los Angeles, Denver, New York City and Washington, D. C., show that all of these cities are large users of the surface heating method for repairing sheet asphalt, asphalt block, asphaltic concrete and sand asphalt pavements. It is difficult to give a cost figure on this type of work that would even approach being general in application. The average range of costs seems to be from 60 cents to 90 cents per square yard for the completed repairs. The results obtained with this heater method have been excellent and, as more of the newer types of asphaltic pavements age, we have no doubt that the surface heater method of repairing will be used to a much larger extent. It is logical for the cities to contract this type of work, as has been proven by those reported as using the contract method. However, San Francisco, which has just completed a program of 1,500,000 square yards, has done its own work with highly satisfactory results.

Analysis of the reports received concerning the use of asphaltic materials for the filling of cracks in cement concrete shows a wide variance of method. In the state and county highway departments there is a distinct trend toward the use of an 85 to 100 penetration asphalt. There is usually, however, a change in the penetration of this asphalt material according to seasonal variations in temperature. Practically all of the

NON-SKID ASPHALT SURFACE TREATMENT ONE YEAR OLD IN WASHINGTON, D. C., CARRYING A TRAFFIC OF 2500 VEHICLES DAILY. CUT-BACK ASPHALT, .41 GALLON PER SQUARE YARD. SLAG CHIPS, THREE-EIGHTHS BY THREE-FOURTHS INCH, 37 POUNDS PER SQUARE YARD. WORK DONE BY CONTRACT AT $0.1015 PER SQUARE YARD.

cities report the patching of broken areas in cement concrete with cold premixed bituminous concrete. Some of them, however, are employing a rich mixture of sheet asphalt and others are using rock asphalt and the various patented types of fine aggregate paving mixtures. A few of the cities still use an asphalt seal coat. The committee believes that standardization in the patching of broken areas of cement concrete should be accomplished at an early a date as possible. We are of the opinion that a spider-web coat of not to exceed one-tenth of a gallon per square yard of cut-back asphalt, followed by placing a cold premixed, fine aggregate type of bituminous concrete, is the best method thus far evolved.

Very few of the larger cities reported any special features that were worthy of study and the committee feels that their modesty has deprived us of considerable knowledge. However, Denver seems to be very proud of its asphaltic "retread" work and Washington points to its macadam patch and reclamation work, in which is used a cold premixed type of asphaltic bituminous concrete. Denver points with particular pride to its maintenance of sheet asphalt and asphaltic block streets, in which the surface heater method is used.

### EXAMPLES OF DURABLE ASPHALT STREETS.

In asking for a report on the oldest asphalt street in the cities, many interesting exhibits were found. The oldest asphalt streets reported are in Washington, D. C., which cites Vermont Avenue from H to I Streets, a sheet asphalt street built in 1870 with a three-inch sheet and an eight-inch coal tar base, and replaced in 1929, with a three-inch sheet on an eight-inch concrete base. Columbus, Ohio, reported that Bryden Road, a sheet asphalt street built in 1888 still is in service and San Francisco points to her Twin Peaks Boulevard as an outstanding sheet asphalt street. Buffalo reported Oak Street, which is of the sheet asphalt type, and San Antonio reported Broadway, a bitulithic pavement. Milwaukee pointed with just pride to Wisconsin Avenue as one of her outstanding sheet asphalt streets and Denver is very proud of a section of Eighth Avenue, built of sheet asphalt in 1897.

The most difficult problem confronting the larger cities in the maintenance of streets, judging from the reports received seems to be the repair of service cuts. It is noted that many of the cities have placed the repair of these cuts under contract but the majority still appear to be doing the work with local forces. The subject of maintenance methods and types of material, will be thrown open by the committee for such discussion as may be desired.

## SECTION II.

### SPECIAL REPORT ON WASHINGTON, D. C., BY MAJOR F. M. DAVISON.

The successful surface treatment of the large mileage of gravel, chert and cinder roadways in the various state and county highway systems is a subject which demands the attention of all engineers. The City of Washington, while its mileage of this type is comparatively small, being, in fact not in excess of 25 or 30 miles, has done considerable experimental work in the surface treatment of gravel roads and the indications are that many of our experiments will prove extremely successful, so much so, in fact, that we are contemplating treating the majority of our gravel streets by the best method of surface treatment we have found as a result of this research work.

There are two types of gravel roads as follows: (1). Those with highly cementitious gravels whose clay content ranges between 15 per cent and 30 per cent. (2). Those non-cementitious or loose, sandy gravels whose clay content is not in excess of 5 per cent. The bituminous surface treatment of the cementitious gravel roads is not an extremely difficult proposition. It is one that resolves itself more into a selection of the proper type of material for use rather than that of the application methods. We have found, in the treatment of these highly cementitious gravels, that a thorough sweeping, in which perhaps a quarter of an inch of the top loose material is removed, thereby leaving some of the larger aggregate bare, is highly advantageous.

### PROTECTING THE EDGE OF THE SURFACE.

We have also found that in the treatment of this type of road, the cutting of a small trench along the margin of the finished surface approximately three inches deep and tapering within 18 inches of the swept grade also is highly advantageous. By constructing such a side trench as above stated, you are in reality applying the maricopa section principle which has been applied so successfully in the construction of concrete pavements. My theory in the construction of this maricopa section is that the edges or margins of the road are the first points to break, due to traffic run, on and off. By forming this trench at the foot of the crown the asphalt that naturally runs from the crown to the side of the roads will gather in this trench instead of running out into the gutter, and the slag cover material, as it whips off, will naturally move to the side of the road and cover this trench. The traffic that runs off the margin of the road comes in contact with a three-inch depth of surface treatment or semi-penetration construction in place of the three-quarter inch thickness of the general surface treatment, consequently this edge will, in my opinion, withstand considerably more abuse than the standard surface treatment, as well as prevent moisture from working under the mat.

Following the sweeping, there should be an application of from thirty-five hundredths to five-tenths of a gallon per square yard, of an oil prime containing about 55 per cent asphalt and with a specific viscosity Engler of 8 to 10. This prime is cut back with an oil distillate or kerosene, in place of the common naphtha cut-backs. We have found after experimental work that oil primes which are cut back with naphthas tend to make a mat which is somewhat brittle with a tendency to crack under traffic and, consequently, we have developed this new oil prime with the distillate cut-back having penetrating qualities equal or superior to tar. We have found upon digging up samples of surface treated, highly cementitious gravel roads whose clay content analyzed 28 per cent, that a penetration of this new oil prime had been secured to a depth of from one-half inch to three-quarters of an inch and that there was no evidence of brittleness.

### CLOSING ROAD AFTER APPLICATION OF PRIMER.

Following the application of the prime, the road should be closed to traffic for approximately three or four hours. By doing this, it will not be necessary to place any "sop-up" coat of sand or other material to absorb the surplus oil which will penetrate into the base in a very short time, if allowed to do so. The seal coat should be an asphaltic naphtha cut-back of approximately 78 per cent asphalt and having a specific viscosity Engler of 18 to 25 at 50 degrees C, with the residue having a penetration of 50. We have found that the use of as heavy a grade of asphalt as this, cut back with a light volatile oil, has been much more successful than the many asphalts which are highly diluted with flux oil. An asphalt with a specific viscosity of 18 to 25, cut back with naphtha, will, under ordinary circumstances, set up within 8 or 10 hours after application and, consequently, will hold over 90 per cent of the cover material.

The application rate on our gravel roads for this seal coat has been from .36 of a gallon to .44 of a gallon per square yard and the rate of application of the cover material, for which we use a standard blast-furnace slag of a gradation size 100 per cent, passing three-quarter inch, with 5 per cent passing three-eighths inch intermediate size, as uniform as possible between the two limits, is 43 pounds per square yard. We have found that this size of cover material is far superior to the smaller sizes that formerly were used in Washington and which are so frequently used elsewhere. The reason for adopting this size of material is that in all asphalt surface treated roads there is a tendency for the asphalt to flush around the cover material and, by using this bigger sized cover material, this becomes almost impossible.

### SLAG SPECIFICATION USED IN WASHINGTON.

There is another reason why we have adopted slag as a cover material and that is its porosity. The argument has been advanced that, because of this characteristic, it is necessary to use from 8 per cent to 10 per cent more bitumen than would be required by using a stone. I admit the fact that it takes a little more bitumen, but in analyzing the situation to see just where it goes, we have found that the bitumen impregnates the pores of the slag and gives a very thorough bond. Consequently it is my belief that this very small additional percentage of bitumen is justifiable.

MASSACHUSETTS AVENUE, WEST FROM SCOTT CIRCLE, WASHINGTON, D. C. THE ASPHALT PAVEMENTS IN SERVICE AT WASHINGTON HAVE GIVEN THE NATION'S CAPITAL THE REPUTATION OF BEING ONE OF THE BEST PAVED CITIES IN THE WORLD.

We have set up a specification for slag, as follows: Weighing not less than 72 pounds to the cubic foot, with the per cent of wear not to exceed 14, and with a French coefficient of not less than 4.4. We have found that the average "whip-off" amounts approximately to two pounds per square yard, but I am of the opinion that I would rather have five pounds too much cover material, which, when it does "whip off," can be picked up and used for other purposes, than one pound too little material whereby a tendency to bleed or become fat would be inevitable.

### Maintenance of Sheet Asphalt Streets.

It is my experience that the rolling of a newly treated gravel road cannot be carried to an extreme and I have adopted the policy of asking the contractor, after he has informed me that he thoroughly has rolled the entire road, to go back and roll it just that much again. This rolling should follow immediately after the application of the seal coat which is covered with slag, since it is possible by prompt rolling to push the cover material well down into the prime coat, while the seal coat is still in a viscous state. The results obtained have been highly satisfactory to the user of the road and the residents of these suburban districts. Because of low cost it is possible to give excellent riding streets, long before it would be possible to lay paving of the standard types formerly used.

Washington uses what might be termed the patrol system of maintenance which covers every asphalt street in the District of Columbia. The patrol force is headed by a competent asphalt repair engineer working directly under the engineer of maintenance and upon him rests the responsibility for the proper maintenance of all asphalt streets. This asphalt engineer has no other pavements to watch except sheet asphalt, asphaltic concrete and asphalt block. The total asphalt mileage in this city (which amounts approximately to 210 miles) is inspected by the engineer in charge of asphalt streets not less than once every two weeks and even more frequently during bad weather. By this method, the need of repairs is detected while the breaks still are in the minor stages. Detailed reports are made of any major repairs deemed necessary and these reports always are passed upon by the maintenance engineer before any great amount of work is done.

### Causes of Disintegration of Streets.

The most frequent causes necessitating repairs may be designated as follows: First, breakdowns from inadequate base support, caused through small surface cracks leading to heaving and sub-surface disintegration. Second, pavement breaks caused by vehicular accidents. As stated above, no major repair to any asphalt street ever is made before the asphalt engineer working under the maintenance engineer or the maintenance engineer himself personally has inspected the location and decided what should be done. While no major decisions are entrusted to the repair foremen, many valuable ideas frequently are secured from them as to methods of repairs, both minor and major. The utilization of asphalt mixes for wearing surfaces upon the streets of Washington is unique in that pavements laid as early as 1879 are still in use. On these, good maintenance records are available covering both major and minor repairs since that time, from a study of which we can forecast at least five years ahead as to maintenance of any major importance.

In most of the replacements on the older types of sheet asphalt, the disintegration of the top has been due generally to the change in traffic weights and conditions acting upon the original base, which base was not designed for present day traffic. For example, a pavement that was laid on a base in 1879 was adequate for the traffic of that day and the estimated increase in traffic for twenty years, but for the traffic which has now developed fifty years after the laying of the original base, it is insufficient. However, one particular street in Washington,—E Street, N. W., from New Jersey Avenue to Fourth Street, which was built by J. S. Baldwin in 1879 with a sheet asphalt top and with a base of bituminous macadam seven inches thick,—still is rendering good service and has a maintenance record of only $.013 per square yard per year after 32 years of use. The first major resurfacing repairs were made by the Cranford Company. They consisted of a thorough burning with surface super-heaters and a replacement with one-inch compacted sheet asphalt top over an area of 5,186 square yards. The cost of this replacement approximated 90 cents per square yard.

The second major repairs to this street were accomplished between 1912 and 1928. They were on the "spot-cutting-out" and "hand-picking" method, largely because of base failures. The cost of this included replacement with a concrete base and the total money expended amounted to $1,723.15. The third repairs of any consequence to this street were made in 1929, and they included burning with the surface super-heater, replacing approximately 52 square yards of old bituminous concrete base with one-three-six mix concrete base and a binder and top at a total cost of $1,713.19.

## ASPHALT REPAIRS UNDER THE DUAL SYSTEM.

In analyzing the record of this street from a maintenance standpoint, it can be seen that the total maintenance cost extending over a period of fifty years is $8,104.74. Reducing this to a yearly basis over a period of fifty years gives us $162.09 per year. Pro-rating this on a square-yard basis for the street gives us a maintenance cost of $.0266 *per square yard per year for fifty years.*

We have another example in Washington of the extra long and economical life of asphaltic pavements in Sixth Street, from Q Street to Rhode Island Avenue, N. W., which is a street of three-inch compacted topping, without binder and laid on a six-inch cement concrete base of *one-four-ten mix, laid in* 1880. The maintenance records on this street approximately are the same as that of E Street, with the exception that this particular street, from Florida Avenue to the river, is a boulevard or through street and carries exceptionally heavy traffic.

The District of Columbia operates its asphalt repairs under a dual system, one phase being on a contract basis per square yard for binder and top-in-place for patches and repairs to utility cuts, including the cutting out and super-heater work where necessary and the complete disposal of all refuse material. We have found that by doing this work under the contract system very satisfactory results have been achieved, especially in the downtown business area. Under the other method the District of Columbia operates two portable asphalt plants for maintenance work in the outlying districts where such plants may be operated without serious inconvenience to traffic. In addition to these plants, it might be stated that we have designed a special type of burner which we believe operates more efficiently than any of those on the market. During the working season these portable asphalt plants manufacture our sheet asphalt topping, for replacement following the burning, at a considerably lower figure than any we are able to secure on the contract basis. However, we have found that it is not practicable to accomplish any maintenance work in the congested areas with portable plants.

We are proud not only of the maintenance work accomplished by our burner method but we are proud of the personnel that has developed the methods now in use. We feel that our burner repair costs are well below the average for the United States.

Below is given a small sketch, Figure II, showing the new design of our burners as differentiated from the common type of burner as designed in Figure I.

Figure I

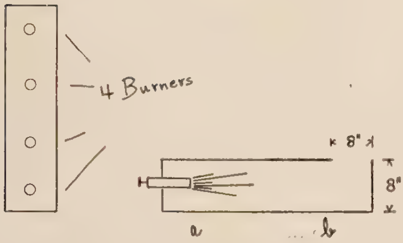
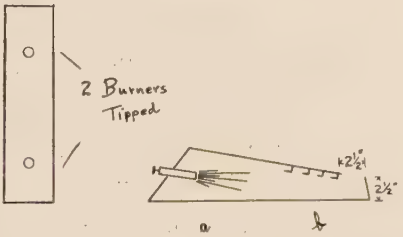


Figure II



You will note in this comparison of designs that our burners hug the pavement closer, decrease the draft at the fire end, increase the height at the flame end and lower the pan at the draft end. With the burner as shown in Figure I, your greatest flame effect is on area (a), while area (b), due to the large draft holes and height of the top of the pan, is only partially heated. In Figure II we have reduced the number of burners from four to two and set them at an angle, increasing the height at the burner end of the pan. The flame not only burns area (a) but, being shot from the burner at an angle, is deflected from the top of the pan and the heat is more uniformly applied to area (b). The draft hole has been decreased from the eight-inch standard to two and one-half inches in order that as little heat as possible may escape.

### USE OF THE SUPER-HEATER DESCRIBED.

We have found that the use of the surface super-heater is not only applicable in repairing sheet asphalt but that it also decreases the cost of either a major or minor repair on bituminous concrete or the "Amiesite" type of pavement. I might state here that by lowering the top of this pan, we burn out a few more pan tops than was formerly the case with the eight-inch clearance burner but the saving in time with the use of the new burner more than offsets this pan top replacement and, with a stock of new pans kept on hand, changes are quickly and easily effected.

We deem it necessary to reach a depth of not less than one inch and preferably one and one-half inches in the application of heat. We have found that by using our new design of burner it is possible with a burner sixteen square feet in area to secure heat to this depth in one and one-half minutes after placement of the burner. This, of course, is on the average asphalt street. When some of the older and dryer type streets are repaired, as well as on the bituminous concrete repairs, it is necessary to allow a little more time. The heat quickly softens the surface so that the old asphalt top can be removed easily and quickly either with shovels or rakes. After the burning and raking has been accomplished and the area to be patched is made to conform to grade, the joints of the area heated should be cleaned immediately so as to remove all foreign matter and so as to impregnate into the hard material at the joint line new asphalt while the heat is retained. A joint of this type will not open during the period of contraction, due to the fact that if adjusted immediately and while the heat is still present the interstices are open and receptive to any asphaltic cement which may be applied. This results in immediate adhesion to the new patch at the joint.

### Repairing Cuts and Ruts in the Pavement.

On the old style of joint, made with a cutting tool, invariably during the contraction period the joint opens, due to the fact that the pressure of the cutter against the joint will close all of the interstices, making it impossible to get true adhesion, regardless of the amount of asphaltic cement applied. A poor joint invariably means a failing patch and hence the greatest attention must be paid to cleaning and shaping the joint line.

Washington, with its almost complete underground construction of utilities, perhaps, has more cuts made in its permanent pavements than any other city of equal size. If I recall correctly, approximately 13,000 permits were issued for pavement cuts last year. Of course, many of these permits covered not only a roadway cut, but a sidewalk and parking space cut, and consequently I assume that we had approximately 20,000 pavement cuts last year. We have found that using the super-heater in repairing these cuts is far superior to the old fashioned cut-out patch.

In major resurfacing repairs, amounting to approximately 100,000 square yards each year, by the use of the surface super-heater, we have found that the old cracks within the heated area are the greatest enemy to the new pavement. They should be cleaned one inch deeper than the general burning grade. If necessary, additional heat may be required along the line of these cracks. The cracks then should be cleaned with a hoe point while the area is still hot and should be filled with pure asphaltic cement up to the burning grade. By following the above method in the treatment of cracks in asphaltic pavements, in line with general resurfacing work, we have found that this extra depth burning and additional application of pure asphaltic cement prevents the old crack from photographing through the newly laid surface. As a general rule our burner repairs consist of the heating and disposal of the top inch of sheet asphalt and replacement with one inch of compacted sheet asphalt.

We have done considerable experimenting in trying to find a method for economical and lasting repairs to ruts in sheet asphalt. So far, the burner has not solved this problem since the displacement is not relaid generally over a larger surface than the actual rut demarkation. The practice that we follow at the present time in repairs to a rut is to strip the pavement to the base for a space of not less than 18 inches on each side of the rut. By this additional stripping we have given ourselves sufficient surface to allow our roller actually to compact the new material rather than to bridge it, as would happen in a narrower repair. Should we encounter ruts inside a heated repair area, it often is necessary again to cut the pavement or to heat it, but in refilling where the ruts have appeared, we have found it best to use only the topping as a refilling material.

In repairing the bituminous macadam and "Amiesite" type of streets, the methods followed are similar to those outlined above. In repairing macadam pavements, especially in connection with the removal of bitumen rolls, pushes and shoves, we have found the ideal method in the burner. We also have made successfully repairs on surface treated macadam streets, where the surface has become fat, through the use of the burner in taking off the old bituminous mat. The failure here being entirely a surface one, burning kills the fatness down to the basic material, but does not materially affect the base material even though it be of a bituminous nature.

### ANALYSIS OF DISTRICT OF COLUMBIA PRIMING ASPHALT.

| | |
|---|---|
| Flash point (Open Cup) | 182 F |
| " " tag | 195 F |
| Spec. viscosity @ 77 F—(25 C) | 62 |
| " " @ 122 F—(50 C) | 12 |
| Viscosity—Furol @ 77 F—(25 C) | 250 seconds |
| " " @ 122 F—(50 C) | 55 " |
| Distillation (Bulb Immersion) | |
| A—Distillate to 437 F (Vol) | 0.0% |
| B— " " 600 F " | 24.0% |
| C— " " 680 F " | 39.5% |
| Tests on Residue from Distillation | |
| Float test @ 122 F—(50 C) | 110 seconds |
| Penetration @ 77 F—(25 C) | soft |
| Ductility @ 77 F—(25 C) | soft |
| Solubility in $CS_2$ | 99.9% |
| First dry spot appearance on surface | 5½ hrs. |
| 80% absorption—or penetration | 8 hrs. |

Base—20 penetration asphalt

Cut back—distillate oil and kerosene

## APPENDIX

### Provisional Specification
### *For*
### Asphalt, Cut Back, for Use Cold in Repair Work.
(District of Columbia)

AR-1-Y.

## I. GENERAL SPECIFICATIONS.

There are no general specifications applicable to this specification.

## II. GRADE.

One grade only is covered by this specification.

## III. MATERIAL AND WORKMANSHIP.

Material supplied under this specification shall be a homogeneous compound of asphalt with a suitable volatile naphtha.

## IV. GENERAL REQUIREMENTS.

The asphalt cut-back shall be homogeneous and free from water.

## V. DETAIL REQUIREMENTS.

Physical and Chemical Properties.

1. The asphalt cut-back shall meet the following requirements:

(a) Specific gravity 25° (25°C.) (77°/77°F.), .......................................0.940 to 0.990.

(b) Specific viscosity at 50°C. ....................................... 18 to 25

(c) Distillation by weight:

(1) Total distillate to 200°C. (392°F.), not more than ............................ 28.0%

(2) Residue at 200°C. (392°F.), not less than.. 72.0%

2. The residue from the distillation test shall meet the following requirements:

(a) Specific gravity 25° (25°C.) (77°/77°F.), not less than ................................... 1.000.

(b) Softening point....35°C. (95°F.) to 55°C. (131°F.)

(c) Penetration at 25°C. (77°F.), 100 g., 5 sec..100 to 150.

(d) Bitumen (soluble in carbon disulphide), not less than ........................................... 99.5%

## VI. METHODS OF TESTING.

Tests of the physical and chemical properties of the asphalt cut-back shall be made in accordance with the following methods:

1. Specific gravity: A.S.T.M. Tentative Test D70-20T; Proc. A.S.T.M., 1920, Part I, p. 764.
2. Specific viscosity (on first 50 cc.): U. S. Department of Agriculture Bulletin 314, p. 7.
3. Distillation Test: A.S.T.M. Standard Method D20-18; A.S.T.M. Standards, 1924, p. 951.

*Note*:—The following modifications in the procedure of the A.S.T.M. method shall be applied:

The distillation test may be made on the sample as received without dehydration, if water is present not to exceed 2.0 per cent, but the results shall be reported on a dry basis. (Par. 2

of A.S.T.M. Method D20-18).

The thermometer shall be placed in the flash so that the top of the bulb is level with the lowest point of junction between tubulature and neck of the flash. (Par. 4 of A.S.T.M. Method D20-18).

For use in the distillation test the thermometer shall be calibrated by distilling (*a*) water, (*b*) chemically pure naphthalene, and (*c*) chemically pure diphenylamine in the apparatus as assembled for a test. When the pure material is distilling at the specified rate and not less than 15 cc. have been condensed, the thermometer reading and a barometer reading are taken. The actual temperatures are calculated from the equations for water, temperature = 100. + 0.037 (mm. barometer — 760), for naphthalene, temperature = 218. + 0.058 (mm. barometer — 760), for diphenylamine, temperature = 302. + 0.055 (mm. barometer — 760). From the observed thermometer readings and corresponding actual temperatures as thus calculated, thermometer readings corresponding to specified fractionating temperatures shall be calculated and used in distillation tests of bituminous materials. (Par. 5 of A.S.T.M. Method D20-18).

The rate of distillation shall be so regulated that 50 to 70 drops pass over every minute. (Par. 5 of A.S.T.M. Method D20-18).

The distillation shall be carried only to 200°C. and fractions reported to that temperature.

4. Softening point: A.S.T.M. Standard Method D36-24; A.S.T.M. Standards, 1924, p. 955.
5. Penetration: A.S.T.M. Standard Method D5-25; A.S.T.M. Standards Adopted in 1925, p. 59.
6. Bitumen (soluble in carbon disulphide): A.S.T.M. Tentative Method D4-23T; Proc. A.S.T.M. 1923, Part I, p. 751.

## VII. NOTES.

1. The material covered by this specification is intended primarily for use with broken stone, slag and sand in the repair of surface breaks, holes and depressions in bituminous type roads, particularly surface treated and bituminous macadam types.

## DISCUSSION.

CHAIRMAN LYON: The committeemen associated with Major Davison, were Mr. Early, Mr. Myers, Mr. Duckett and Mr. Delano. If any of those gentlemen would like to add anything to this paper we would be glad to hear from them. Any discussion?

MR. J. T. PAULS, Washington, D. C.: I wonder if Major Davison would describe in more detail the nature of the cut-back materials which were used on this work. I believe it is true as a general proposition that the light residual or topped crude oils of the 50 to 60 and 60 to 70 per cent grades are used most extensively in the West for priming although some gas-oil tar is being used in Oregon, particularly in the vicinity of Portland. In the East the use of light tars predominates. More recently, however, soft asphalt cements cut back with kerosene have been tried out and seem to be proving highly successful. I believe this type of material offers numerous possibilities for this purpose, due to its great penetrating qualities.

**Major Davison**: The prime oil that we spoke about is a new development. We do not feel sure enough about it to put out a specification about it as yet. I might say that I had about twelve or fifteen thousand gallons of it put down as an experiment to stabilize both traffic-bound macadam roads and loose gravel roads. The prime is about a fifty-to-sixty asphalt content cut-back and, instead of its being cut back with naphtha, we are trying out a method of cutting it back with furnace oil, or what you call gas oil. I believe myself that it has all the penetrating proclivities of tar, because I went out on a very cold day, cut out a section and examined it. I have the section upstairs in my room and any of you that may be interested can see it. However, we do not feel that a specification should go out as yet. It is a little too early. We would like to see the experiment go through one winter or longer before we make any claims. I think it is better to put your feet on the ground and shuffle along rather than to jump at conclusions. This prime that we have used so far has been very satisfactory. The only trouble about it is that it smells like something terrible.

**Chairman Lyon**: Is Mr. Hinkle of the Indiana Highway Department in the room? He was to lead the discussion.

**A Delegate**: Mr. Hinkle was not able to attend and he asked me to express his regrets. The treatment in Indiana has been covered very fully by the report of the committee.

**Mr. C. L. Motl**, St. Paul, Minn.: Mr. Chairman, I think the papers cover maintenance of pavements more than maintenance of roads. A great many states are using surface treatments extensively. In Minnesota about four or five years ago we started giving surface treatments and we now have about thirteen hundred miles of such treatments on all types of roads, starting with gumbo, mixtures of clay and sand and on sandy soil. We were rather skeptical as to the success of our program because our first inspections of that kind of work did not seem to indicate that such methods would give the desired results. We started out with three rules governing a surface treated road and these three rules were good maintenance, more maintenance and better maintenance. We felt that these surface treated roads would never be satisfactory until some method of maintenance had been developed that would give the public a good surfaced road all the time.

A good many engineers have looked at our roads and have been surprised that we were carrying more than two thousand vehicles a day on a road with a surface treatment less than three-quarters of an inch thick. They were surprised also to find very few holes in the road. We feel that we have developed a perfect method of maintenance, one that can be used all the time and that will not inconvenience the public. Our surface treated roads are divided into sections of twenty or thirty miles, with a man in charge of each section. Maintenance, which consists of blading and dragging, starts immediately after the construction work is finished and continues as needed. On account of the difference in judgment of the section men as to the maintenance requirements we have eliminated entirely the use of liquid material. Each section man is provided with a stock pile of treated material which varies according to the requirements of his section of the road. All that he need do is take his shovel, truck and treated material, go out on the road and put on a patch. Occasionally we find small corrugated areas and, in order to avoid waiting for heavy equipment to come around once a year, we are scarifying and surface treating each section before any break occurs. We have discovered that we can scarify and reshape a wrinkled surface during most of the year and get very good results without the addition of any new material.

Our cost data probably is a little different than that of others. We use the gallon as the basis for estimating costs, for we have discovered that the gallon is the only measurement consistent for all roadway widths. Our treatments cover roadways that vary from twenty to forty feet in width and when we try to figure materials on the squard-yard basis we have had difficulty in estimating the necessary amounts for the man in charge. We worked out a method of getting at the costs on a per-gallon basis founded upon experience. In other words, a gallon of bituminous material being used, all the other materials necessary to provide the surface treatment were estimated in connection with this gallonage basis. By this method the cost of initial treatments per gallon, including the preparation of the road-bed and furnishing the binder and all incidentals, runs about fourteen cents a gallon. Now, if the section man desires to use a half-gallon, or three-quarters of a gallon, he is at liberty to do it and every engineer who goes over the road to estimate his requirements estimates on the half or three-quarter-gallon basis, the cost being proportional. We find that this method is very successful, particularly in providing the section man with a sufficient stock pile or premixed material. The section man goes over his section of the road daily and as soon as a small hole develops it is plugged.

The same patrol system applies to a paved road. We once had the crews go over our pavements twice a year. The result was that by the time we finished going over a pavement quite a few holes would develop and, in order to do a thorough job, we usually had to go back to the material shed. So we evolved a method of using section men on our paved roads. These section men now go over the paved roads daily and weekly and, just as soon as any defect appears on his section of road, each man attends to it without delay. I think that is scoring a success on paved roads.

CHAIRMAN LYON: Any further discussion, gentlemen, of this interesting paper?

PROFESSOR J. S. CRANDALL, Urbana, Ill.: I should like to ask Major Davison if that fifty-nine-year-old pavement on Vermont Avenue in Washington was analyzed to find out what was in it? I would also like to call the attention of the meeting to the fact that, notwithstanding that this pavement was probably the oldest in the country, being fifty-nine years old and made out of "black base," yet, when they replaced it and laid the new pavement, they put it on a concrete base.

MAJOR DAVISON: In answer to that question, let me say that we have in this room right now the man who was the chief engineer for the District of Columbia. I think he has just completed forty years' service there and I am going to let Mr. C. B. Hunt, former chief engineer of the District of Columbia Highway Department, answer that. Will you not please tell him about that, Mr. Hunt?

MR. C. B. HUNT, Washington, D. C.: I did not pay very close attention to the question. I would like to ask just what the question was.

PROFESSOR CRANDALL: I would like to know if the old pavement was analyzed when it was taken up?

MR. HUNT: Do you mean the base?

PROFESSOR CRANDALL: I mean the base and the surface also. I presume it had been resurfaced at some time.

MR. HUNT: Portions of it had been resurfaced but the larger portion of it had not. The base was a coal tar base and was analyzed, I am sure, because such a sample as that naturally would be. That work came under the direction of the engineer of tests. By the way, he ought to be here. I think it was analyzed; in fact, I know it was. I cannot give you the results because I am not a chemist in any sense. I did have charge of this pavement from 1897 until the time it was taken up. The reason for putting in the concrete base when the street was restored was that we had all agreed on concrete for city base at least. That goes almost without saying. In the District of Columbia we use the concrete base as standard practice. We do not now have available the coal tar installation that we had then. Coal tar was practically all that could be used in those days. The original asphalt pavements that we laid in Washington dated back to sometime before that and in those days we laid them all on the coal tar base. There was no hydraulic concrete at the time. We had some natural concrete later but the stages in which the development of bases came were first, the coal tar base; next, the natural concrete base; then the hydraulic concrete base.

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CHAIRMAN LYON: Gentlemen, we are all very much interested in this discussion but we were late in starting this morning and by your permission we will go on. The next paper is by Mr. W. E. Hawkins, construction engineer of the North Carolina State Highway Department, on and deals with the subject of "The Sand Asphalt Pavements of North Carolina."

# The Sand Asphalt Pavements of North Carolina

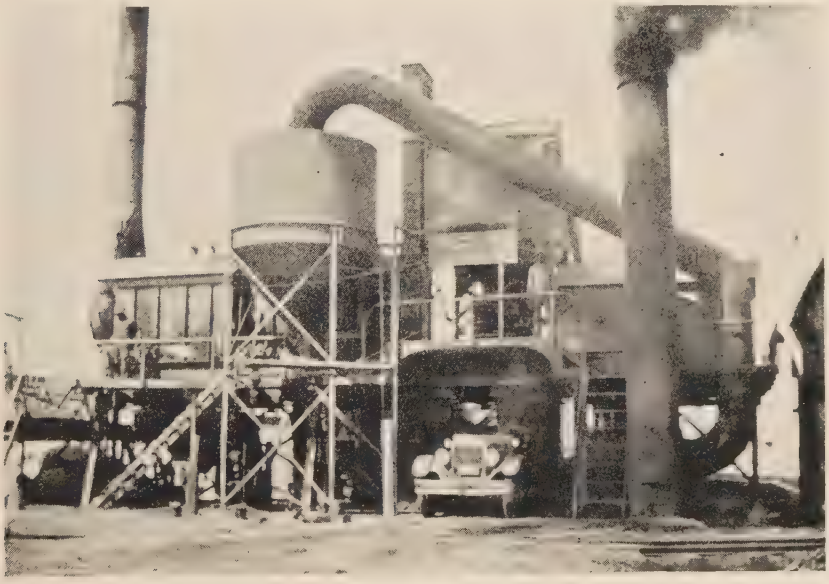
## By W. E. Hawkins, Raleigh, N. C.

*Construction Engineer, North Carolina State Highway Department*

The problem confronting any state having a large road building program is the difficulty experienced in obtaining an adequate supply of materials that will be satisfactory for construction purposes. Some states are fortunate in having natural deposits of suitable material located in many sections within their boundaries, while others have a limited supply which must serve the requirements for the entire state. In the geological formation of the eastern part of North Carolina there are no stone or gravel deposits available. Top soil, sand-clay and bank gravel are of such inferior quality that they are unsuitable for surfacing purposes. This section of the state has a limited population that is spread over a large area, with many miles of roads connecting the small towns and communities.

### DIFFICULTIES CONFRONTING THE ENGINEERS.

When our large road building program was inaugurated in 1921 this situation confronted the State Highway Commission. Funds available for construction purposes were very limited in these undeveloped sections and to consider the building of a hard surface pavement would have been unwise. The excessive cost of the transportation of materials made the construction of this type prohibitive. Likewise the volume of traffic did not justify a very expensive road. Along the eastern coast of the state and for quite a distance inland, there are vast areas of sand. The problem, therefore, was to develop some type of pavement in which this local material could be utilized. In the late spring of 1922 experiments were conducted with mixtures of local sand and asphalt and the results were so satisfactory that a continuation of this type of construction was warranted. The subsequent developments were such that during each year since the inauguration of this type of construction an additional mileage has been constructed in sections of the state wherever local sand was available and subgrade conditions were suitable for this type of pavement.



Plant Set-up for Sand Asphalt Pavement Construction in North Carolina.

In the contemplated construction of a sand asphalt project the primary investigation should be to ascertain whether or not suitable sand is available near the proposed work. The sand should consist of clean, hard, durable grains that are free from clay, loam and other foreign matter. The gradings of the sand used on several recent projects were as follows:

| | *Project* 3831 | *Project* 3200 | *Project* 3680 |
|---|---|---|---|
| Retained on 40 mesh sieve.......... | 20.4% | 41.6% | 25.0% |
| " " 80 " " .......... | 38.8 | 35.3 | 45.6 |
| " " 200 " " .......... | 35.6 | 21.1 | 24.8 |
| Passing 200 .......................... | 5.2 | 2.0 | 4.6 |

It is essential that uniform gradings be maintained between the 40 and 200 mesh, as this will permit the utilization of a finer sand which can be used in this type of work. The most satisfactory sand is one which approximates closely the grading used in sheet asphalt. Sand of this quality is very rarely available and, therefore, it is necessary that care be exercised in balancing the proposed mix. This is accomplished by determining carefully the percentage of voids and establishing a formula in the laboratory which properly will fill the voids. By this method it has been found that sands unsuitable for sheet asphalt, due to wide variation from standard grading, can be used satisfactorily in sand asphalt when none other is available.

### Proper Preparation of the Subgrade.

The character and preparation of the subgrade is a very important factor in the construction of sand asphalt. In the early stages of this work it was deemed expedient that the subgrade be of loose sand but in later years it was found that a sand-clay subgrade, and in some cases a grade with a high percentage of clay, would make a suitable foundation if proper drainage was provided. The subgrade should be compacted uniformly and firmly and brought to a firm, unyielding surface before any hot mix is placed thereon. All unsuitable material encountered in the subgrade, such as excessive clay, vegetable matter and detrimental soil, should be excavated and replaced with a satisfactory material that will become firm and compact.

After the completion of the rough grading, timber forms are set firmly to line and grade. These forms are two inches by eight inches, long or short leaf pine, cypress or other satisfactory lumber, ten to fifteen feet in length. The forms are staked securely and left in place after the pavement is completed. Following the form-setting a small gang of men prepares the subgrade and completes the fine grading. The base course mixture, composed of 7½ to 8 per cent asphalt, penetration 50-60 and 92½ to 92 per cent sand, is prepared at the plant and delivered to the road in trucks at a temperature of from 300 to 350 degrees Fahrenheit. This mixture is dumped upon a sheet metal dump board and shoveled into place on the subgrade. The hot mix then is struck off by a finishing machine to the proper shape and section and, after the material has cooled sufficiently, the base course is rolled with an eight to ten-ton tandem roller until the material thoroughly is compacted, the rolling starting longitudinally at the sides and gradually proceeding toward the center of the pavement. The base surface should be smooth and all irregularities should be patched before the final rolling. From one to two days' run of base course is permitted and this is followed by the placing of the surface course.

A squeegee coat of hot asphalt, penetration 50-60, is spread on the base course prior to the laying of the surface course. The asphalt is heated in a kettle to a temperature of from 300 to 350 degrees Fahrenheit and applied at the rate of 1/12 to 1/16 gallon per square yard. This squeegee coat is absolutely essential in order to insure a proper bond between the base and surface courses. The surface course mix, of 10 to 10½ per cent asphalt, 8 to 12 per cent filler dust and 82 to 79½ per cent sand, is delivered to the road, spread and struck off by a finishing machine to the proper shape. The same weight of roller is used as on the base, the rolling being done longitudinally and followed by diagonal rolling in two directions.

Preparation of Sand Subgrade for Sand Asphalt Pavement Construction. North Carolina State Highway Department.

### Nature of Base Course Construction.

The base course is laid to a compacted depth of three inches, while the surface course is two inches in depth. The finished surfaces of both courses are checked with a ten-foot straight-edge during rolling operations and repairs are made where necessary in order that the final surface will be smooth and uniform. Previous to the final rolling of the wearing surface and while the pavement is still warm, a light coating of limestone dust or Portland cement is swept over the surface and the rolling is continued until the surface course thoroughly is compacted. The density of the base course averages from 1.80 to 1.95, while the top course averages from 1.95 to 2.10. These average densities are results of projects that have been constructed in recent years.

The asphalt mix is controlled on each project very accurately by a field laboratory in charge of an inspector. In addition, samples of each day's work are forwarded to the laboratory in Raleigh and checked for A. C. content, sand gradings and density. Should there be any distinct variation between the results of the samples and the daily reports of the inspector, an investigation is made at once. The construction details on the road are controlled by a roadway inspector. Daily reports are made by both inspectors as to the progress of the work. The plants used in this type of construction are similar to plants used on other asphalt work except in the size of the cylinders or drums in which the sand is heated and dried. The size and design of the heating drum is an important factor in the output of the plant.

### SET-UP FOR HANDLING MATERIALS.

We have constructed many projects on which the plant set-up was adjacent to the railroad. In these cases the plant is located near the sand pit and shipments of asphalt and filler dust are unloaded from the plant siding. The sand is transferred from the pit to the plant by means of a gas crane and a three-quarter-yard clam-shell bucket. On projects away from a railroad the plant is erected at the sand pit and the asphalt is hauled in tanks, trucks or barrels and the filler dust in sacks. In the construction of a project recently completed near Wilmington, N. C., the asphalt was hauled by trucks for a distance of thirty miles, while the filler dust required a nine-mile haul. Storage tanks equipped with heating coils are erected at the plant so that a reserve supply of asphalt may be kept on hand.

CONSTRUCTING SAND ASPHALT PAVEMENT IN NORTH CAROLINA. PLACING FIRST COURSE SAND ASPHALT MIXTURE.

In recent years sand asphalt pavements have been constructed 16 and 18 feet in width at a cost ranging from $1.12 to $1.34 per square yard. In consequence of this low cost construction, many sections of the state have had roads improved, the building of which would not have been possible had a higher type of construction been considered. At present there is being constructed in North Carolina a sand asphalt project which is unique in many respects. This project is situated on a narrow peninsula of land which borders on the Atlantic Ocean and is separated from the mainland by large bodies of water, known as sounds. The road is being constructed as a connection between the mainland and Roanoke Island on which is located Manteo, the seat of government of Dare County.

In the past it has been necessary for the inhabitants of the island to depend upon water transportation as a means of trading and other contact with the outside world. Privately owned boat lines and ferries were operated on established routes. During the past several years the roads on the island have been improved and a bridge constructed between the island and the peninsula. The public sentiment aroused by these improvements caused an agitation for the building of a road that would serve as an outlet to the mainland. The only feasible location for this road was through an isolated, barren section adjacent to the ocean coast and as sandy as the Sahara Desert.

Machine Finishing Sand Asphalt Surface. North Carolina State Highway Department. A Close Up View Showing How the Surplus Material is Kept Against the Screed at All Times.

### Nature of Local Materials Utilized.

An interesting phenomenon of this section is the manner in which particles of sand from the ocean shores are carried by winds of high velocity and deposited in dunes of great height which cover acres of ground. Realizing that the funds available for the building of a road in this isolated section would necessitate the utilization of local material, we made a number of tests of local sand to determine if sand asphalt construction were feasible. The average results of the grading of the dune sand were as follows:

Retained on

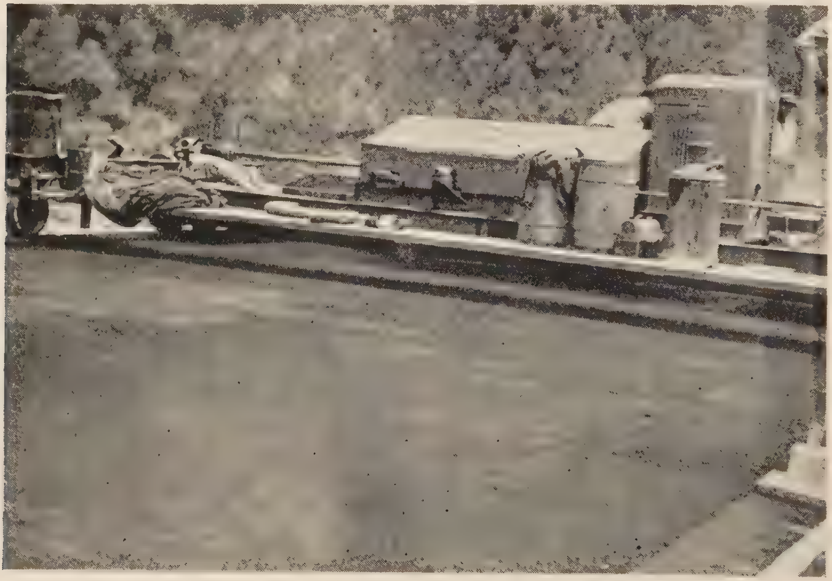
| | |
|---|---|
| 40 mesh sieve | 2.70% |
| 80 “ “ | 64.60% |
| 200 “ “ | 32.70% |
| Passing 200 mesh | 0.00% |

Tests were made of other deposits of sand, of which there were many varieties. It was found that the material located on the ocean beach near the high water mark averaged in grading as follows:

Retained on

| | |
|---|---|
| 10 mesh sieve | 2.00% |
| 40 " " | 49.80% |
| 80 " " | 36.20% |
| 200 " " | 12.00% |
| Passing 200 | 0.00% |

When these sands were combined in the proper proportions they produced a mixture that would meet the grading requirements for a sand asphalt pavement.



Machine Finishing a Sand Asphalt Surface. North Carolina State Highway Department. Showing the Surface After Screeding.

After this preliminary investigation, the project, which was 10.7 miles in length, was advertised and in April, 1930, was awarded to the R. G. Lassiter Company of Raleigh, N. C. All the equipment used in the building of this project was shipped by rail, then transferred to barges and transported by water to a pier, located at Nag's Head, Roanoke Sound, constructed especially for this work. Shipments of asphalt in drums and filler dust in paper sacks were transported by barge, unloaded at the pier and hauled by truck to the work. The plant was located adjacent to the road about 4½ miles from the beginning of the project and at the base of a large sand dune. The gas crane, equipped with clam-shell bucket, was placed on an elevation so that excavating into the sand dune was accomplished with little trouble. The coarse sand was hauled from the ocean beach and deposited within reach of the gas crane.

### HAULING MATERIALS TO THE JOB.

When this work first was considered the problem of hauling caused some apprehension. This was overcome by the use of one and one-half ton Ford trucks equipped with dual tires. By inflating the tires about one-half the required pressure, the trucks transported a two-ton load over the deep sand with little difficulty. In the preparation of the base mix the sand was combined at the rate of one part beach sand to four parts dune sand and 7½ per cent asphalt. The wearing surface mix was composed of one part beach sand to three parts dune sand, 10½ per cent asphalt and 7½ per cent filler dust.

During extremely hot weather some difficulty was experienced in rolling both courses. The hot mix, when placed on the sand subgrade, would transmit the heat to the sand and when an attempt was made to roll, the mix would be displaced and distorted. It was necessary to wait until night before rolling could be completed. Similar trouble was experienced in rolling the surface course but during the autumn months the change in temperature allowed rolling to be completed several hours after the last material had been placed. The results with sand asphalt have been so satisfactory on this project that public sentiment is demanding an extension that will complete the road on the peninsula.

CONSTRUCTING A SAND ASPHALT PAVEMENT IN NORTH CAROLINA. ROLLING THE BASE COURSE.

This road transverses an historical section. It serves as an outlet to Roanoke Island on which is located Fort Raleigh, the first settlement in America made by English colonists in 1584. Here also was the birthplace of Virginia Dare, born in 1587, the first white child born in America of English parents. Adjacent to this road also is located Kill Devil Hill, a sand dune from which the Wright Brothers made their first experiments in flying during the years 1900 and 1904. This spot has been memorialized by the Federal Government, provision having been made to preserve the hill by planting shrubbery, trees and vegetation. On this hill a monument will be erected at a cost of $250,000, the money having been already appropriated. The contract for erection will soon be awarded by the government.

### Sand Asphalt Giving Good Service.

This project is described in particular because of its unusual construction details and its characteristically local conditions. In other sections of the state many miles of sand asphalt pavements have been constructed which also are rendering satisfactory service. Changes and improvements have been made from year to year in details of construction which have been for the betterment of sand asphalt work. At present some consideration is being given to one course construction. Experiments have been made in depths ranging from three inches to five inches compacted but on account of difficulties experienced in rolling the mix with an eight to ten-ton tandem, no conclusions have been reached until a three or four-ton tandem has been tried out with pavements of various depths.

Maintenance of these pavements has consisted of surface repairs, filling cracks and repairing defects in the sub-base, caused by improper drainage conditions. These imperfections developed in the first pavements constructed. In recent years changes have been made in the details of construction which have resulted in an improvement in the sand asphalt. In some cases the maintenance costs on sections of this pavement are exceedingly moderate. During 1924 there was constructed a five and one-third mile project of sand asphalt, located between Aberdeen and Southern

Finished Sand Asphalt Road. North Carolina State Highway Department.

Pines. The traffic between these two points ranges from 800 to 1000 vehicles per day. The only repairs necessary to this pavement have been an occasional filling of the surface cracks. The pavement at present is in excellent condition and is rendering satisfactory service. There are similar sections which have required very little maintenance.

The width of pavement on the original projects which were started in our state in 1922 was ten feet. A large portion of this mileage has been reconstructed by adding three feet of sand asphalt base on each side and the entire width of sixteen feet resurfaced. The ten-foot width served traffic purposes for a period of years but on account of an increase in the volume of traffic, it became necessary to widen the old pavement. Other sections of the original construction have been resurfaced by flush-coating an application of bitumen and covering with ¼ inch to ¾ inch stone chips at the rate of 25 pounds to the square yard. This method of repairing was tried out as an experiment but it has been very satisfactory.

If local sand is available in any community, subgrade conditions are suitable and the volume of traffic does not justify an expensive high-type road, a sand asphalt pavement will be adequate to meet all future requirements. Since 1922 North Carolina has constructed approximately 500 miles of this type, and the results have been so satisfactory that the adoption of this type of construction has been more than justified.

CHAIRMAN LYON: There is one more paper, gentlemen, by Mr. H. C. Holden, district engineer of the State Department of Public Works in Massachusetts, on this same subject. We will now ask Mr. Holden to come forward.

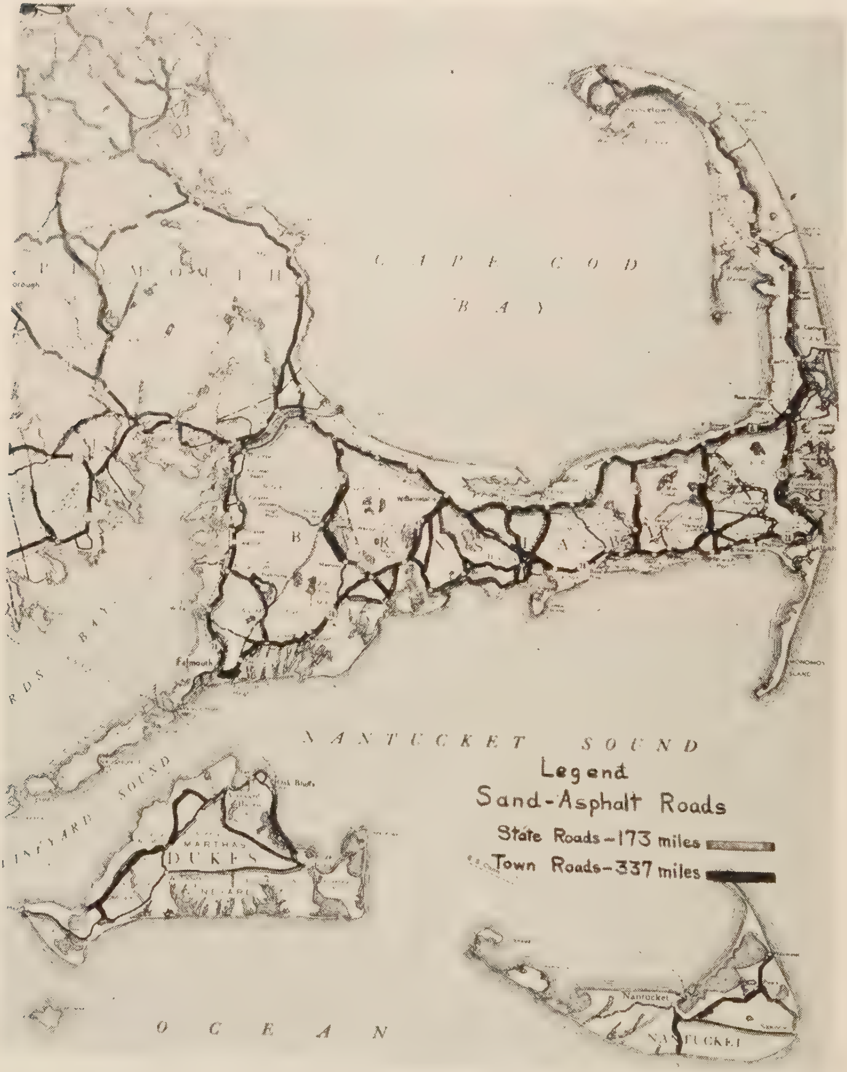
# Sand Asphalt Roads in Southeastern Massachusetts

**By H. C. Holden, Middleboro, Mass.**
*District Engineer, Massachusetts Department of Public Works*

The peninsula forming the southeastern extremity of Massachusetts and embraced in Barnstable County is known best as Cape Cod. Its location, contour and importance early gave it the sobriquet of "The Right Arm of Massachusetts". Since the early days it has become so popular as a summer resort that it is often designated as "The Playground of the Nation."

The ground surface at the Cape is quite undulating in character but the easterly end is hilly. It is enough so that several short sections exist on our state highway system that indicate a six to seven per cent grade. The contour of the Cape also includes various indentations by bays and harbors. The geological formation of the Cape could, in general, be classified as "drift". On the northern shore and on the shore of Buzzard's Bay are boulders of granite. This condition exists also on the center-line of hills in Brewster and Dennis counties. However, there are no ledge deposits and the small amount of local stone in the walls and boulders is too soft for highway purposes. There are a few small deposits of sandy gravel. In general the soil is sandy. There is an extensive deposit of clay in the town of Truro, running from North Truro across the Cape to Highland Light.

Every Cape woodland shows the effects of strife with the winds by the stunted growth of the oak and pine which are the prevailing trees where the woodlands exist. The effect of the heavy winds readily can be imagined, as they scour and erode the sand slopes and necessitate continuous road maintenance. In the summer months the sea breezes prevent excessively high temperatures and have the same effect on low


CAPE COD BAY
PLYMOUTH
BARNSTABLE
Falmouth
MONOMOY ISLAND
NANTUCKET SOUND
VINEYARD SOUND
BUZZARDS BAY
Oak Bluffs
MARTHAS
DUKES
Nantucket
NANTUCKET
OCEAN
Legend
Sand-Asphalt Roads
State Roads–173 miles
Town Roads–337 miles

Road Map of Cape Cod, Massachusetts, Showing Location of Sand Asphalt Roads in That Region.

temperatures in the winter. Frost generally leaves the ground several times during the winter months, so that freezing and thawing are nearly continuous. Snow fall is not heavy but at times the snow drifts badly.

### LAYER AND MIXED-IN-PLACE SAND ASPHALT.

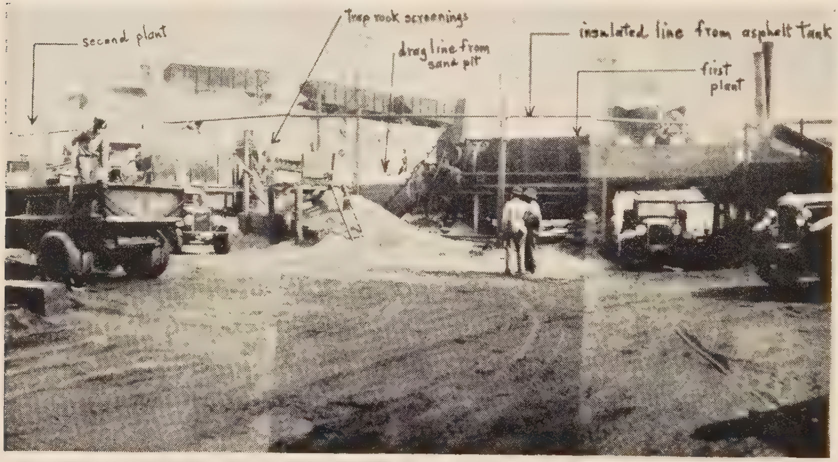
The first sand and oil road constructed in Massachusetts by the Massachusetts Highway Commission was in the town of Eastham on Cape Cod in 1905. The old road surface consisted generally of sand of various grades. It was shaped roughly with a road machine preparatory to applying the oil for about sixteen feet in width. The oil used was about 85 per cent asphaltic oil. The methods used were interesting. Compared with that of today the application was very crude. An upright tank, similar to an enlarged hogshead, was used as a container and hauled by four horses. The subsoil was harrowed with a disc or wheel harrow and it is easy to imagine how it was rutted by the wagon and holes caused by the hoof imprints of the horses. The flow of asphaltic oil was regulated by a gate valve which controlled the amount delivered to a distributor pipe having holes bored through it, the holes being about one-half inch in diameter and about three inches apart. The only pressure was the weight of the asphalt in the container, so instead of our getting a spray the oil flowed in streaks. A slight improvement was made with this method of distribution a few years later when asphaltic oil was distributed through nipples onto a splash board and thence to the road surface.

The method of constructing this sand asphalt type of highway con-consisted generally of two applications of about ¾ gallon to the square yard, the first application being covered with sand and then back-covered daily until the bleeding stopped. After this the surface was broomed as clean as possible and the second application made. This type, with constant maintenance, produced an uneven road surface and now is only built occasionally by towns in Barnstable County on unimportant roads. However, at the present time the subgrade is hardened and properly shaped and the bituminous material is applied with uniform distributors under proper pressure.

In hardening the subgrade no method of proportioning the loam and clay has been adopted. In using the word "loam", let me say that loam on the Cape is reddish in color rather than black and is very light in consistency. About four inches of the hardening material generally are used and the average price is 75 cents per cubic yard. Where possible, suitable hardening material has been obtained by excavation. The object of constructing this type of highway in Barnstable County was to produce a low cost highway. Local stone was scarce and imported stone for waterbound macadam was expensive. The first cost of this layer type was not high but maintenance proved to be very high. A smooth surface was not obtained and is not obtained even today.

### FIRST MIXED-IN-PLACE SAND ASPHALT

In 1909 the first "hand mixed-in-place," sand asphalt type of road was constructed. The bitumen in the mix was about 90 to 100 penetration. The sand was obtained from the roadside and from nearby pits. Stone, up to two inches in size, was used in the mineral aggregate. This method of construction was followed until 1913. The mix generally was spread on the subgrade in one course about four inches thick before compression. The operation of mixing was carried on by placing a fixed volume of sand in a box, similar to the old time mortar-box, adding the proper amount of 90 to 100 penetration asphalt and raking it back and forth until the sand particles were coated. This mix was wheeled in barrows or carted to the highway and then spread. The asphalt content was about 5 per cent. After spreading, it first was rolled with a hand roller and then a horse roller. A final rolling at some later time was made with a ten-ton three-wheeled macadam roller. The sand was heated by piling over pipes which were about two feet in diameter and generally about twenty feet long, wood being used for fuel. The fires were started some two hours before mixing and an additional laborer was required to keep turning the sand so as to help in the heating and avoid burning.



Plant Set-up for the Construction of Sand Asphalt Roads Near Brewster, Mass. Massachusetts State Highway Department.

The oldest highway of this type now in use in Massachustetts is on U. S. Route No. 6 in the town of Sandwich. This surface was placed in 1913 and since then it has received two surface treatments of ¼ gallon each of 85 per cent asphaltic oil. Each time it was covered with clean, sharp sand. At the present time in the Massachusetts State Highway System, the Sandwich project is the only hand-mixed surface of this type which has not been resurfaced, except one very short section in the town of Mashpee. The Sandwich highway today is narrow and super-crowned and probably soon will be discontinued as a state highway. A new by-pass is being constructed around the town of Sandwich. Observation showed that the mix in this type in places was not wholly satisfactory. It was difficult to obtain a thorough and uniformly coated mixture. To help this situation this type of surface was sealed with two applications of 85 per cent asphaltic oil, each application being about ¼ gallon to the square yard.

Our early observation of this type of surface caused us to feel that we had created a type that was suitable for Barnstable, Dukes and Nantucket counties and a portion of Plymouth County and that it was cheaper than waterbound macadam and much better adapted to the locations where it could be used.

### Development of Sand Asphalt Mixture.

From 1913 to 1922 the small types of portable mixer and dryer were used with one exception. Very little attention was given to selecting sands which were properly graded. In general a fairly coarse, clean sand was used in the mix. The one exception to this was in 1917 when 5 to 10 per cent by volume of Portland cement was added to the mineral aggregate. Naturally this somewhat increased the asphalt content. At this time it was decided that while excellent results were obtained by using the Portland cement as a filler, we felt that results also were satisfactory from using local sand and the cement filler increased the cost of the surface beyond the value received.

The asphalt content in the mix where the portable mixers were used without the cement filler was about 5 per cent. With the cement filler the asphalt content was about 5.6 per cent. Until 1920, on all of the so-called sand asphalt mix surfaces, upon completion of the surfacing, the surface was sealed with two applications of ¼ gallon each of 85 per cent asphaltic oil and the surface covered after each application with sand.

Prior to 1921 the mix type of surface always was placed in one course. Very often during the summer months the section placed in the afternoon was not rolled until the following day. This did not give proper compression and in a short time traffic created inequalities in the surface.

Preparation of Subgrade for Sand Asphalt Pavement. Massachusetts State Highway Department.

The lack of using side-forms, together with the excessive crown and narrow widths, caused the edges to break down under traffic. Today, with the lesser crowns and the use of wooden side-forms on the top course and with the base course slightly widened, the breaking down of the edges has been corrected. With our present day methods, one marvels at the results obtained with the one-course method and the lack of forms.

Many miles of old waterbound macadam were widened by placing a four-inch course on the sand shoulders and reducing the thickness gradually to a feather edge where it met the waterbound macadam. This, of course, created a peculiar type of surface, with from six to eight feet of waterbound macadam in the middle of the highway, the remaining areas being of sand and asphalt mix, or bituminous concrete, as we now designate it. After these surfaces were sealed it was impossible to distinguish which surface was waterbound macadam and which was bituminous concrete.

### Problem of Increasing the Stability.

In 1921 it was decided to make extensive experiments in order to see just what should be done to improve this type of surface and in 1922 extensive experiments were conducted in Wellfleet. It was our endeavor to ascertain just what should be done to increase the stability. We desired to prevent displacement of the surface when loaded vehicles stood upon it during the season of high temperature. Certain factors were important, namely those of load, time, temperature, the depth penetrated by the load and just what should be added to the mineral aggregate so as to increase the stability of the surface.

At this time the highway department had no laboratory and no research department. Therefore, to ascertain this, we used the rod penetration method, which, briefly, is a rod of a certain cross-section area held in position by a small tripod. This rod is weighted with a definite weight over a fixed period of time and definite additions to the weight are made for fixed periods of time. These experiments with time and load applied were carried out at approximately the same temperatures, thus obtaining comparative results from the different mineral aggregates used. These consisted of sand, stone screenings and hydrated lime in various amounts. Of course, we had no method of arriving at density determination other than visual inspection. However, a very careful observation of the time of loading and the temperature of the mix on the road surface was kept.

Further describing the tripod, rod and weights, let me say that the rod was square and ½ inch in cross-section. The tripod had two small arms at its top, so that we could impose lead weights on the rod. The lead weights varied in size from five pounds down to one pound, the additional weights being added so that the determination of the load could be had before displacement started. The tripod was made up of thin steel bands with a small welded piece on the bottom of the legs about two inches square. The asphalt content in the various mixes used in this experimental work varied from 5 to 6.5 per cent by weight. At this time it was found desirable to place the surface in two courses and we used side and center forms of wood. The practice of using forms has been continued and is in vogue at the present time.

The original rollings were done with a six-ton tandem roller and the final rollings were made with a ten-ton, three-wheeled macadam roller. It was found that the same results were obtained with the tandem as with the three-wheeled roller. This conclusion was arrived at by the use of the rod penetration method and comparing the load, time, temperature and penetration. The use of this simple device also provided an approximate idea of the impact or stability value where these experiments were tried. First the rod was applied to the road and as nearly uniform blows as possible were used. A record was kept of the number of blows and the character of the results was studied. From these various experiments was created our present "Type A" bituminous concrete specifications. I should add that many screen tests of sand were made and curves plotted on cross-section paper and thus we determined the most desirable grading of the sand particles.

Construction of Sand Asphalt Pavement in Massachusetts. Placing the Two-inch Wearing Course.

### Description of Present Methods

It is the custom to set up asphalt plants at points where sand, which constitutes over 60 per cent of the mix by weight, is available. Ordinarily, asphalt and stone screenings, the other two ingredients of the mix, are hauled from rail delivery points to the points of set-up. In selecting a pit it is important especially that test pits of sufficient size and depth be made and that sufficient screen tests be made also to be sure that the supply is abundant and meets the requirements of the specification for the particular type of mix to be used. It can be seen readily that each particular project may create a different set-up. Carelessness in testing the supply of sand and its requirements so as to conform to the specifications has caused, in one case at least, added expense to the contractor, since it became necessary for him to haul his sand some distance to his plant.

In 1930, the State Department of Public Works reconstructed the state highway on U. S. Route No. 6 in the town of Brewster. This project was about eight miles in length and the preliminary estimate called for nearly 30,000 tons of bituminous concrete surfacing of "Type A." The construction company doing this work made a special effort to develop a set-up that was economical and efficient. The final decision was to make a set-up at a point where sand was available beside a railroad in order that asphalt, stone screenings and sand could be supplied without the necessity for hauling any of the material. Such a location was found, permitting a set-up as described. A location was selected where the sand occurred at an elevation well above a feasible floor to serve as the plant site. This permitted the economical conveyance of the sand to the plant. This location was well below an elevation adjacent to the railroad. No public siding existed. Therefore the construction company built a siding at the location offering the topographic advantages that were deemed essential.

### Nature of the Plant Set-Up.

This location provided a reasonably smooth floor for the plants and easy access to the state highway project. The sand occurred in a bluff, making it possible to develop a face upward of forty feet for excavating the sand. The stripping of the sand pit was used as filler for the railroad siding. To this was added the necessary excavation required for setting

Construction of Sand Asphalt Pavement in Massachusetts. Rolling the Surface Course.

up the plants. The rail of the siding was approximately 35 feet above the floor at the plant set-up. Certain conditions existed so that the rate of production of the mix required more than one plant of the size available. Therefore two plants were operated and the problem of getting three materials to two plants at a minimum cost was solved. The delivery of asphalt, which was from the tank cars on the siding to the plants, involved only the problem of piping.

The problem of getting the two mineral aggregates for the two plants was not simple. One of the plants had an "A" conveyor permitting feeding at two points about thirty feet apart. The other plant had a single conveyor operating in a vertical plane through the axis of the dryer. Since sand predominated in the mineral aggregate arrangements were made so that the sand could be delivered for both plants at one point. A rough hopper was constructed with its top approximately ten feet above the floor. A drag-line supplied the sand to the hopper. Two gates in the hopper supplied the sand for the two plants.

Stone screenings were taken directly from cars on the siding by a belt conveyor which discharged at the plant nearer the track. Ample head room created a storage area for a liberal supply of stone screenings. The hopper at the end of the bucket-line carrying the screenings was sheathed and provided with a gate. The screenings from the belt conveyor, therefore, simply piled up around the hopper and the feed was operated merely by regulating the gate. It manifestly was impossible to arrange the plant so that both sand and stone screenings could be picked up at one point. Therefore, a second belt conveyor was erected, extending over the dryer of the plant nearer the railroad siding and delivered at the hopper to provide the feed for the plant farther away. This arrangement provided delivery at either plant. The delivery also could be split up in any way desired. This set-up, I think, was more efficient and economical than any previously made.

### Control of the Mixture by Specification.

The control of the mix and the variations allowed now are controlled entirely by the specifications. Samples are sent to the laboratory twice a week, screen tests are made on the ground by the resident engineer in charge as well as by the laboratory and the specifications are strictly adhered to. If the chemist's reports show that the sand and stone dust do not meet the requirements, immediate steps are taken so they will meet the standards of the specifications. The same applies to the asphalt content.

Transportation of the mix to the road today is not a problem that requires inspection. The use of high speed trucks now provides a method of transportation that permits long hauls to be made successfully. If the haul is so long that there is a chance for the load to cool, the load is covered with canvas. We require that the mix shall not be below 150 degrees F. when spread. Invariably the temperature is higher. The mix is dumped on steel platforms or suitable dumping boards and is entirely rehandled in spreading. The dumping boards have to be placed ahead of the mix so that when the spreading is done, the dumping board is entirely free and none of the material is pulled laterally or any mix is left that can be spread laterally. In other words it has to be completely rehandled.

The raking is done carefully and, after the initial rolling, the surface is straight-edged in the same manner as occurs in cement concrete. In the initial rolling the roller is driven parallel to the center with a slight deviation from the line as it approaches the mix that has just been spread.

Completed Sand Asphalt Pavement. State Route No. 6 Near Orleans, Mass.

Our specifications require that the rolling shall be continued at the rate of not more than 100 square yards of wearing surface per hour for each hour of rolling on the finished surface. Also our requirements are such that a ten-foot straight-edge, laid parallel to the center line of the road, or on any part of the surface, shall not show a deflection from the true in the surface that will exceed one-fourth of an inch.

## Preparation of the Foundation

Our foundation requirements for this type of surface are the same as for any type of surface. There is a peculiar condition on Cape Cod, since the foundation generally is of sand and it becomes necessary to harden the subgrade with from four to six inches of loam or mixed loam and clay. This naturally gives rather a flexible subgrade. However, continuous rolling and smoothing and finishing of the subgrade, gives a subgrade of proper cross-section, firm and hard.

The 1930 specifications require a composite screening test as follows:

*Composite*

Passing ¾ inch screen..................................100%
Passing ¾ inch screen, retained on ¼ inch screen 1% to 17%

| | |
|---|---|
| Passing ¼ inch screen, retained on No. 10 screen | 6% to 26% |
| Passing No. 10 screen, retained on No. 30 screen | 20% to 68% |
| Passing No. 30 screen, retained on No. 100 screen | 7% to 45% |
| Passing No. 100 screen | 0% to 15% |

The 1930 specifications require an asphalt content of 5.5 to 6.5 per cent by weight. Laboratory reports showed the following stability test, all of which are on 1930 projects:

Halifax. Considerable ¼-10 mesh. Asphalt content 5.41%. Stability 2775 pounds per square inch.

Brewster Reconstruction. Average asphalt content on four samples 5.91. Average stability 1741.

Bourne-Sandwich Construction. Average asphalt content on four samples 5.89. Average stability 1750.

Provincetown Construction. On this project 40% of stone screenings was used. Asphalt content 6.13. Stability 2425.

Careful preparation, prior to the erection of the plant, by making tests of sand and stone screenings mixed, prevents any question that may arise while the work is in progress. If the contractors feel sure that they must meet the requirements of the specifications there is very little difficulty in following them. On a few of the projects in 1930 the composite screen test required an additional amount of stone screenings. In such cases these were added without additional expense, inasmuch as the stone screenings were cheaper than a long haul to a suitable pit.

## Use of Ground Limestone as Aggregate

In the past, some experiments have been conducted with the use of ground limestone in place of stone screenings. The use of ground limestone produces a surer continuity of uniformity. To illustrate just what I mean, let us assume that the hopper is of sufficient size so that thousand-pound batches can be mixed. If limestone is shipped in bags it generally comes in bags that weigh 100 pounds. This means that a proper amount of limestone dust can always be added. A visual inspection of various sections that were constructed by using limestone indicates a slightly more stable surface and I am of the opinion that in the long run the operation can be reduced slightly in cost by using limestone rather than stone screenings. My reason for believing this is that the limestone is not heated. It is added to the hopper direct from the bag, so that both elevators can be used in raising the sand to the dryer.

It has been found that the output in general is slowed up slightly because one elevator does not carry sufficient sand to the dryer when the second elevator is used for raising stone screenings, so I feel that a greater output can be obtained, even though it will be necessary for a few revolutions of the pug to mix the sand and limestone dust before adding the asphalt.

## Construction and Maintenance Costs

Within the counties of Barnstable, Plymouth, Dukes and Nantucket the mileage of the above type of highway, on November 30, 1929, on state highways was 172.9 miles. This length comprises 2,091,114 square yards. The average cost per mile of this type of surface, which is 4½ inches in thickness, in two courses 24 feet in width, sealed with ¼ gallon of asphaltic oil and covered with sand, is from $21,000 to $24,000. In specifying the cost the surface cost is the only part which should be described, as the cost of grading, drainage, etc., varies in different locations.

The following table shows a four-year period in cost of maintenance per mile and per square yard for this type of surface:

| *Year* | *Miles* | *Sq. Yds.* | *Cost Per Mile* | *Cost Per Sq. Yd.* |
|---|---|---|---|---|
| 1926 | 132.28 | 1,474,107 | $46.81 | $ .0042 |
| 1927 | 141.79 | 1,595,804 | 53.88 | .0048 |
| 1928 | 157.93 | 1,847,210 | 45.68 | .0039 |
| 1929 | 172.91 | 2,091,114 | 58.05 | .0048 |

This particular type of highway has been constructed by different municipalities within these four counties in cooperation with the state and county on what we designate as "Chapter 90" highways, but which, after their completion do not become state highways. Their construction, however, is supervised by the State Department of Public Works. The number of miles of this type of highway in District No. 7 is 336.7 miles, exclusive of state highways. Traffic on these highways, of course, is variable, being very much lighter in the winter than during the months of July and August. The Bourne-Sandwich highway, previously mentioned, showed a traffic count for sixteen hours a day in August that had a maximum on Saturday and Sunday of about 13,000 vehicles. Please understand that the greater part of this vehicular movement consisted of pleasure vehicles.

### USE OF CRUSHED GRAVEL AND PEA STONE.

There are many miles of surface in southeastern Massachusetts which have been constructed by crushing gravel and using the larger product of the crusher for a base course, filling the voids in the base course with a finer aggregate or penetrating this base course with refined tar or asphalt, over which has been placed a mixed top course of two inches in which is used the finer aggregate from the crusher product. One of the desirable qualities of this type of surface is the simplicity of repairs. It is a very simple thing to cut out the top course and with a small plant, such as is used by the ordinary highway maintenance units, replace the surface.

This particular type of surface is adapted to any location that is not subject to a heavy truck traffic. It will carry almost any reasonable load as long as the load is kept moving. In Barnstable County the load limit allowed by law is ten tons or 20,000 pounds, including the vehicle. It is, however, very important that special attention be given to the grading of the aggregate and that such fillers be added to the sand as will give a correct grading. If careful inspection is given to the placing of the surface and the rolling and finishing, this type of highway will prove to be very satisfactory.

On several of our projects in 1930, after the bitumen was applied for the seal coat, the sand covering was distributed through sand spreading machines, the sand being passed through the dryers at the plants and heated to about 225 degrees and then spread on the highway while hot. I feel that this gave a better seal coat than the previous method of stacking the sand on the sides of the highway and spreading by hand. The hot sand had a tendency to take up all of the asphalt that it would absorb and we thus avoided back-covering. During 1930, on nearly all projects of the bituminous macadam type in the district, pea stone has been spread in the same manner as above outlined, except, of course, that the pea stone was not heated.

Sand Asphalt Pavements in Massachusetts. Showing Winter Conditions to which Such Pavements are Subjected. The Scene is Near Dennis on Cape Cod During the Winter of 1930.

## FOURTH SESSION

### Hotel Peabody, 9:30 A. M., Thursday, December 4, 1930

### Hugh W. Skidmore, Past President, the Association of Asphalt Paving Technologists, Presiding

Chairman Skidmore: The meeting will be in order. This is one morning we will begin on time and without any preamble whatever we will open the program with the first paper that was on yesterday afternoon's session, "Mixed-in-Place Gravel and Crushed Stone Roads in the West," by Mr. J. T. Pauls, senior highway engineer, United States Bureau of Public Roads, Washington, D. C.

# Mixed-in-Place Gravel and Crushed Stone Roads in the West

**By J. T. Pauls, Washington, D. C.**

*Senior Highway Engineer, United States Bureau of Public Roads*

Doubtless the development of the "mixed-in-place" method of construction, in part, is responsible for the great progress made during the last few years in the improvement of secondary roads. It is, however, impossible at this time to describe with any degree of detail the many different types of low cost road construction on which the "mixed-in-place" method has been used. This paper, therefore, is confined largely to construction and the results obtained with the use of crushed stone and gravel in this type of work in the far western states. While the construction of roads by this method is being adopted quite extensively, particularly in the so-called "retread" construction and the fine-graded, top soil road mixes in the middle western and eastern parts of the United States, the types of bituminous materials, the mineral aggregates used as road metal and the resultant road surfaces in the West are quite different from those generally used in the East.

Typical Unloading Plant with Boiler, Retort and Storage Tanks.

In western construction the aggregate is obtained either by scarifying the old base or by adding new material, or by both scarifying and adding new material. The bituminous material is applied in about one-half gallon applications by pressure distributors until the desired amount has been spread. Discing immediately after each application generally is done, which not only aids effectively in the mixing but also prevents the freshly applied oil from adhering to passing vehicles. After the required amount of oil has been added the materials are mixed further with blading machines by repeatedly windrowing and spreading until all the aggregate is covered and the mix is uniform in appearance. Areas that are lean are given an additional application of oil and then are remixed. In the same manner areas which are too rich are remixed with additional aggregate.

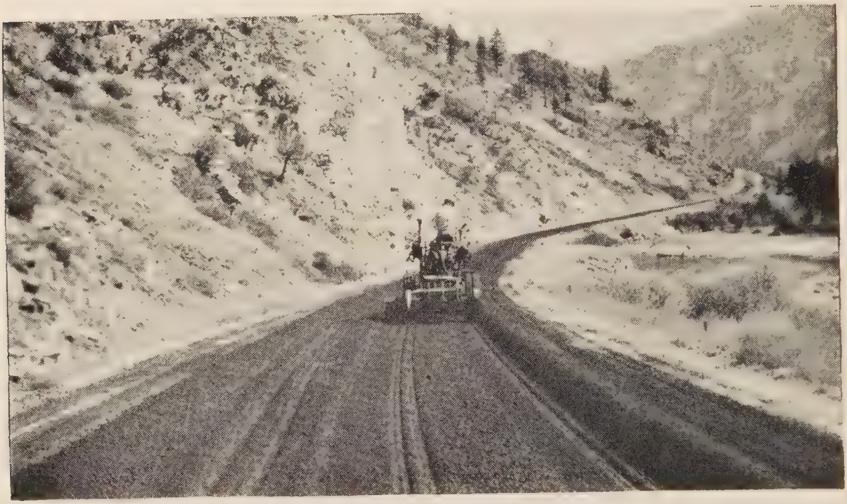
### NATURE OF THE MIXING OPERATIONS

To aid in handling traffic, that aggregate generally is placed in two windrows along each edge and mixing completed on each, after which they are combined and remixed in the center of the road, thus allowing the passage of traffic throughout the complete operation. Speed and plenty of power are essentials in efficient mixing. When the mixing operations are complete the mix is spread to a uniform cross-section for compaction, which may be secured either by rolling or by traffic or both.

A DISC HARROW GENERALLY IS USED AFTER EACH APPLICATION OF BITUMINOUS MATERIAL.

Generally, it is advisable to roll the surface when a heavy bituminous material, such as a cut-back asphalt or asphalt emulsion, is used. The thickness of the finished surface ranges from one and one-half to three inches compacted, with a majority of the work two inches thick. Washington seems to be the only state using the minimum thickness and this may be explained by the fact that this type of construction in Washington is regarded as more of a temporary improvement, later to be strengthened by surface treatments or replaced by a higher type of construction. Washington also applies a prime application of the light oil to the base, which, no doubt, not only strengthens the base construction but the surface as well. However, with the exception of Washington, there seems to be a growing tendency to regard three inches compacted as the minimum thickness necessary to give a satisfactory surface mat.

The type of aggregate used in this construction includes both gravel and crushed stone of a maximum size of about one to three-quarters of an inch and graded to dust. With the use of the light oils it is necessary to have high inherent stability and interlocking of the fragments, while, with the heavier bituminous materials, this is not so important. With the former material the custom is to have 5 to 10 per cent or more of the material passing the 200-mesh sieve, while, in the latter, the crusher-run material should prove highly satisfactory. Although the maximum size of the aggregate given above is that which is generally used, the indications are that the maximum size of stone used in this type of work should not be larger, particularly for the light oil material and might satisfactorily be considerably smaller. There is a tendency for the coarser particles of aggregate to be loosened from the surface and thrown to the edges by traffic. It is believed that a smaller maximum size would reduce the segregation and subsequent raveling.



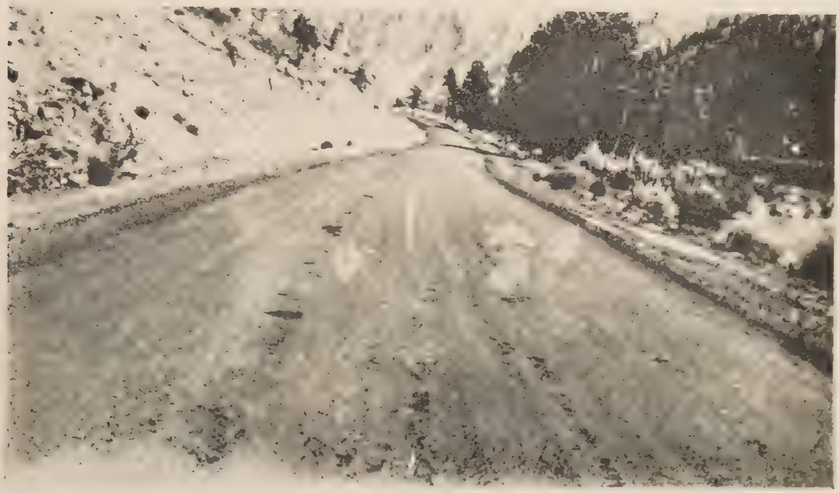
A ONE-MAN POWER-DRIVEN BLADE GENERALLY IS USED TO COMPLETE THE SPREADING AND SMOOTHING AFTER COMPLETION OF THE MIXING.

### GRADING OF THE AGGREGATES

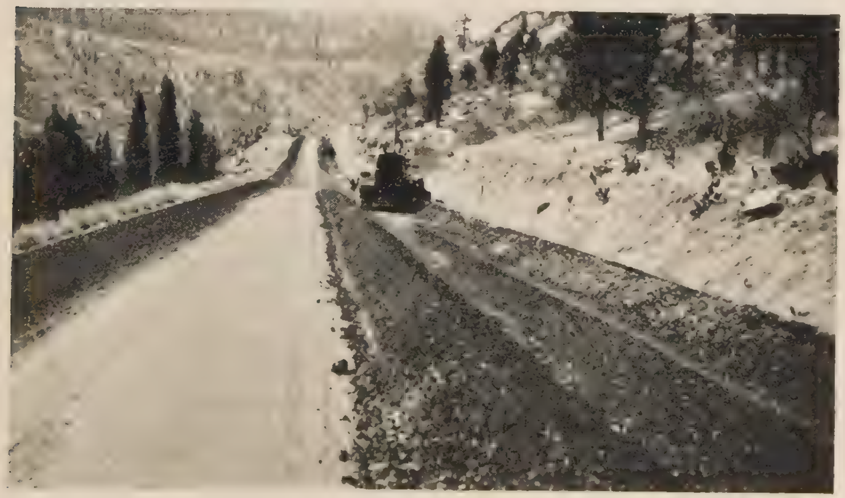
The following table gives the average grading of the crushed stone and gravel aggregate, as well as the amount of oil used in typical oil-mix projects in several states:

| | Per cent by weight passing | | | | Oil used *Per cent* |
|---|---|---|---|---|---|
| | 1 *in.* | ¼ *in.* | 10 *mesh* | 200 *mesh* | *By Wt.* |
| Wyoming | 95.3 | 69.5 | 50.9 | 7.0 | 4.3 |
| New Mexico | 98.9 | 75.5 | 58.0 | 5.9 | 4.3 |
| Idaho | | 50.6 | 37.3 | 6.1 | 4.0 |
| Utah | | | 35.5 | 7.8 | 3.7 |

The quality of the aggregate is important, particularly with the use of light oils. Until recently the material was considered satisfactory when the fines had a cementing value of not less than 100 by the Page impact test, a moisture equivalent of not more than 20 per cent and a lineal shrinkage of not more than 5 per cent. More recently it has become evident that these requirements did not indicate definitely the suitability of the aggregate for light oil mixing. A considerable number of rapid failures on these roads, which at first were believed to be due to the character of the oil, particularly as to the quantity of paraffin contained, after more careful study, have been determined definitely to be due to



Pot-Holing and Raveling Develop in the Surface when Insufficient Oil is Used in Construction. A Remedy for this Condition Requires Either Remixing with Additional Oil or Application of a Surface Treatment.



Mixing in Two Windrows to Permit Traffic to Pass During Construction.

the character of the aggregate. Experience with the light oil mix construction shows that there is a tendency for a slow rise of the oil to the surface even under dry conditions, necessitating the remixing of the surfacing as frequently as every two or three years and, where moisture conditions are not so favorable, the rate of this movement is greatly increased. It is believed that where rapid failure of the surfacing has occurred that a considerable percentage of the aggregate has been of the character possessing low affinity for the oil, with the result that water easily displaces the oil and causes a very rapid movement of the oil to the surface.

Mixing with Blade Machines Follows Immediately After the Final Application.

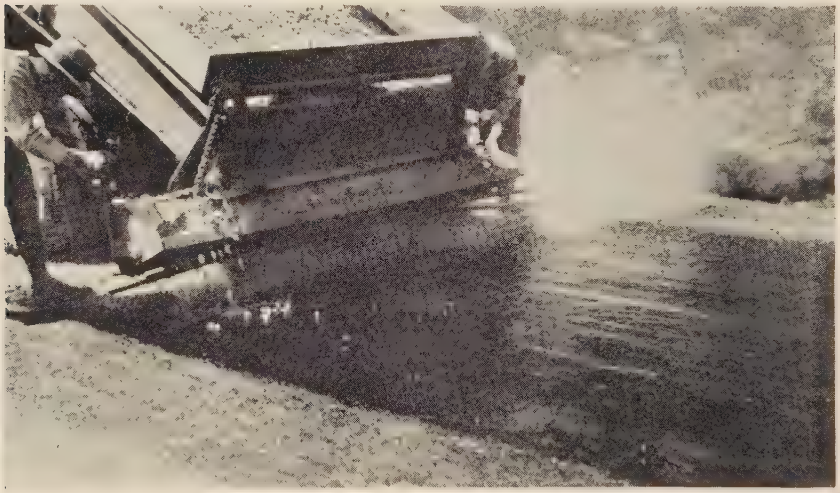
Federal-Aid Project No. 295-B in San Luis Valley, Colorado, is a striking example of rapid and complete failure from the combined effect of bad moisture conditions and unsuitable aggregates for the light oil mix treatment. This project, which is about ten miles in length, was constructed with crushed gravel and 60 to 70 per cent oil in the fall of 1929. During the following spring the surface failed completely from rutting, shoving and raveling and it was only with frequent remixing, as often as every two weeks, that the surface was kept passable during the early part of the summer. The unusual behavior of this construction undoubtedly is due to the aggregate, since an adjoining "mixed-in-place" project on the same road and under identical conditions, except for a different aggregate, has given excellent service for three years without very appreciable maintenance.

## Testing of the Aggregates

Several of the western states now recognize the importance of the aggregate in connection with the light oil mix construction and are determining the behavior of the various aggregates in the oil mixture before attempting their use in this construction. A test along this line recently has been devised to determine the preferential absorption of the aggregates for water and oils and thereby the suitability of the aggregates for light oil mixing. This test is known as the "swell test" and was first used by Mr. Powers of Arizona. The method for making this test in the Bureau of Public Roads laboratory is to mix the aggregate with approximately the amount of oil that would be used in the construction work. One thousand grams of the mixture then are placed in a cylinder four inches in diameter and six inches high and molded under a pressure of about 2,000 pounds per square inch. After compression the specimen is left in the mold and a slip cover, made of No. 40 mesh sieve supported in a frame, is placed flush against the under side of the mold. The mold containing the specimen then is placed in a water bath so that there is one-eighth inch of clearance from the bottom of the tank. The water level in the bath is kept about one inch above the surface of the specimen, while the specimen in the mold is covered with about one-half inch of water. The amount of swelling is measured on the top of the specimen by means of an Ames dial, contact with the specimen being made by a thin metal disc one inch in diameter. Readings are taken at regular intervals until maximum swelling is obtained. A swelling of as little as one-sixteenth of an inch indicates that only mediocre success can be expected from the use of the particular aggregate. Aggregates entirely unsuitable for mixing have given swelling as great as three-quarters of an inch under the conditions of this test.

Light Oils Rise Slowly to the Surface of the Mix Under Normal Conditions, Requiring Periodic Remixing Every Two or Three Years to Redistribute the Bituminous Material in the Aggregate, with Aggregates Having a High Affinity for Moisture, and where Moisture Conditions are Unfavorable, Failure of the Surface May Develop Rapidly. The View Shown is Typical of the Rapid Movement of the Oil to the Surface, Due to These Conditions and not to the Richness of the Mix.

Another test for the suitability of the fine aggregate is the so-called "emulsification test." The method essentially is to combine 10 grams of the fines passing the 200-mesh sieve with 50 c.c. of 60-70 per cent road oil which has been warmed to a temperature of 130° F. in an eight-ounce, wide-mouth bottle. The mixture then is stirred for five minutes with an electric mixer having a rotating paddle. At the end of five minutes 100 c.c. of water, heated to 130° F., is added to the oil mixture and the stirring continued for an additional five minutes. In this test unsatisfactory fines will separate from the oil and will be deposited at the bottom of the jar while the satisfactory material will remain coated in the oil. In a comparison of the test results and the surface behavior of the light oil mix type of construction, built with aggregates on which tests have been made, we believe the results indicate definitely that these tests may be used to determine the suitability of the aggregate for light oil mixing.



Surface Treatments Often are Applied to Old Oil-Mix in Preference to Remixing and Adding More Oil. An Attachable V-Type Spreader is Used to Advantage on this Type of Work.

## Determining the Necessary Amount of Oil

The amount of oil necessary to give a satisfactory surface depends largely on the grading and character of the aggregate and to some extent on the type of oil used. The finer the material the more oil is necessary. This also is the case when the aggregate is of a character that absorbs the oil. Generally, the heavier the bituminous material the more is required. Allowance also should be made with the use of cut-back materials for a certain per cent of loss of the solvent used. Several methods are being used by the various states to determine the amount of oil necessary. First, the "cut and try method," namely, that of determining the amount of oil on a short portion of the road and using this as a guide in conjunction with the grading of the aggregate determined periodically for the remainder of the road. Various formulae, based on the surface area theory, such as the one developed by McKesson and Frickstad, have come into use. The McKesson and Frickstad formula, used with a stain test, was developed primarily on the basis of the experience in Southern California. The tendency, particularly in colder climates, is to use considerably more oil than is called for by this formula and considerably better results are being secured.

The McKesson and Frickstad formula for determining the amount of oil necessary is as follows:

$P = .015a - .03b - .17c$

Where $P$ = percentage of oil required

$a$ = percentage of aggregate retained on 10 mesh sieve

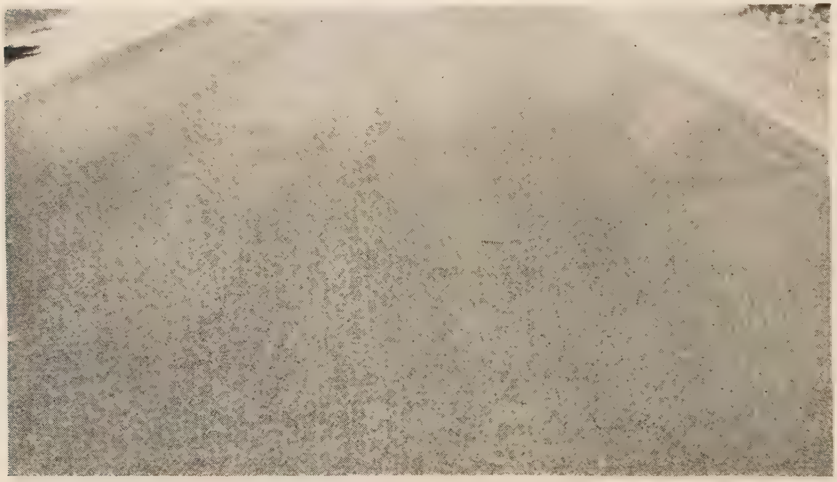
$b$ = percentage of aggregate passing 10 and retained on 200 mesh sieve, and

$c$ = percentage passing 200 mesh sieve.

A Mixed-in-place Surface in which a 70-80 Per Cent Road Oil was Used. With the Higher Asphalt Content There is an Appreciable Increase in the Plastic Qualities of the Mix.

Wyoming, Utah, and New Mexico have all used the McKesson and Frickstad formula with factors which give a greater percentage of bitumen than is called for by the basic formula. California has recently developed the following formula: $P = .020a - .045b - .18c$, where a, b and c have the same values as in the earlier McKesson and Frickstad formula. However, there are certain alternative values for the factors where the grading is not typical and the character of rock also must be considered. While these various formulae aid in approximating the proper amount of oil, no general adoption of them is possible without a thorough knowledge of local supplies and local climatic conditions.

The amount of moisture in the aggregate is important in determining the amount of oil, particularly if the appearance of the mix is taken as a guide, since a small amount of moisture is all that is needed to give the mix a false appearance of excessive richness. The light oil products so far used in the oil mix treatments come from a number of fields, chiefly in California and Wyoming. So far neither the service behavior nor laboratory tests have shown the material from any one field or the method of manufacture to have any important effect, on this type of construction. The various light oils so far used have been of the types obtained by straight topping of the crude petroleum, residues from steam distillations and residues or by-products of different cracking processes. The oil mostly used contained 60 to 70 per cent asphalt of 80 penetration and of a specific viscosity (Engler at 122° F.) of about 50 to 80. With the higher viscosity the practice generally is to heat the material to aid in applying, particularly during cold weather.



Cut-Back Asphalt with Kerosene has been Used in Mixed-in-Place Construction with Both Crushed Stone and Gravel of Various Gradings. The View Shown is a Surface Appearance Obtained by Using Crushed Stone from One to One-Eighth of an Inch in Size. It is Believed that with this Type of Bituminous Material the Crusher Run Aggregate or the Equivalent would be Most Economical and would Prove Entirely Satisfactory.

### Standard Specification Adopted

As a step towards standardizing and simplifying the requirements for road oils, a conference of the highway officials of several western states was held at Portland, Oregon, in February, 1930. Of the several specifications adopted as standard, the following specification for road oils for "mixed-in-place" construction was agreed on:

| | |
|---|---|
| Asphaltic residue of 80 penetration | 63+ |
| Viscosity, Saybolt-Furol at 122°F. (sec.) | 200-300 |
| Float test at 25°C. (sec.) maximum | 200 |
| Flash point, Pensky-Martens (°F.) minimum | 225 |
| Water and sediment (per cent) maximum | 2 |
| Bitumen soluble in $CS_2$ (per cent) minimum | 99 |
| Bitumen insoluble in $CC1_4$ (per cent) minimum | 99.65 |

Although the light, slow drying oil products have been used almost exclusively in "mixed-in-place" construction in the West, it has been the belief of many that the use of a heavier binder would give better results in this type of construction, particularly on roads carrying fairly heavy traffic and those where moisture, climatic conditions and the aggregates available are not entirely favorable. With this in mind a number of experimental sections recently were built by California in cooperation with the Bureau of Public Roads in which two grades of asphaltic materials, a 94+ asphaltic road oil and a 100 to 120 penetration asphalt cut back with kerosene and a slow drying asphalt emulsion were used.

A TYPICAL LIGHT OIL "MIXED-IN-PLACE" SURFACE IN EXCELLENT CONDITION AFTER TWO YEARS' SERVICE.

Although it is too early to draw final conclusions from these experiments and other recent work as to the suitability and limitations of these materials in this type of work, the early favorable results obtained, particularly with the asphaltic materials cut back with kerosene, seem to indicate that these cut-back materials will prove highly satisfactory on this type of work with aggregates of the approximate size and grading now used in light oil mixes.

### SPECIFICATIONS FOR CUT-BACK MATERIAL.

Typical specifications for two grades of cut-back materials suitable for this work are as follows:

> The finished products shall be made from a 100-120 penetration asphaltic cement and a 94+ per cent asphaltic road oil complying with the specifications for these respective base materials.
>
> For the finished product:

| | 94+ *Per cent*<br>*A. R. O.* | 100-120<br>*A. C.* |
|---|---|---|
| 1. Specific gravity 25°/25°C. not less than | 0.950 | 0.950 |
| 2. Flash point (°C.) open cup, not more than | 80 | 80 |
| 3. Specific viscosity (Engler) 50 cc., 50°C. | 50-80 | 50-80 |
| 4. Bitumen soluble in $CS_2$ (%), not less than | 99 | 99 |
| 5. Bitumen insoluble in 86° Baume naphtha | 5-22 | 5-22 |
| 6. Loss at 163°C., 5 hrs., 50 gm., not more than | 20% | 25% |

| | | |
|---|---|---|
| Residue from loss at 163°C. should have a float at 50°C. (sec.) | 80-180 | not less than 100 |
| 7. Asphaltic residue of 80 pen., not less than | 75% | 70% |
| The solvent to be kerosene having a flash point not lower than 115° F. (closed cup) and end point on distillation not higher than 625° F. | | |

Such data as are available indicate that the cost of the oil mix treatment, exclusive of aggregate, ranges from $1000 to $2000 per mile for an eighteen-foot width of two to three inches compacted depth. This does not include the cost of macadam which varies considerably, depending largely on the cost of the aggregate in place. For a large amount of this work under a wide range of conditions the cost for a five to six-inch compacted macadam course ranges from $3500 to about $4500 per mile.

BOTH CRUSHED STONE AND GRAVEL ARE USED IN THE "MIXED-IN-PLACE" TYPE OF CONSTRUCTION. THIS VIEW SHOWS A SURFACE IN WHICH A COMBINATION OF UNCRUSHED WASHED GRAVEL, ONE AND ONE-EIGHTH TO ONE-EIGHTH INCH IN SIZE, AND A CRUSHED GRAVEL, NINE-SIXTEENTHS OF AN INCH TO DUST, WAS USED—A MIXTURE HAVING ABOUT 11 PER CENT PASSING THE 200-MESH SIEVE.

As to the cost of maintenance of the oiled roads only meager information is available. However, such as there is seems generally to indicate that the treated roads are economical in comparison with the untreated. On approximately some hundred miles of light oil mix roads in New Mexico, one to two years old, the average cost of maintenance was found to be approximately $200 per mile. In Wyoming, during 1928, the cost of maintenance averaged $330 per mile, while in Idaho, during the same year, 600 miles of untreated macadam cost $285 per mile, exclusive of material replacement as compared to $294 per mile on 200 miles of oil treated surfaces.

## Conclusions Drawn From Studies.

In conclusion, I believe it can be said that: (1) The "mixed-in-place" method as constructed in the West gives unexcelled riding qualities to the surface. (2) This method of construction is adaptable to many types of aggregates and slow drying bituminous materials. (3) The results obtained compare favorably under the best conditions with those obtained with plant mixing, for the generally used aggregates and oils. (4) The development of a satisfactory portable road-mixing equipment for handling the aggregate directly from the road windrow may be expected in the near future. This further should increase the possibilities of the "mixed-in-place" method of construction for use with certain types of material which are not entirely suitable for the present machine mixing. (5) The light oil "mixed-in-place" treatment is proving highly satisfactory in the arid and semi-arid sections, while in the colder and more moist areas results have not been so favorable. (6) The character of the aggregate, rather than any difference in the light oils, is believed to be responsible for the occurrence of many rapid failures, particularly under moist conditions. Preferential absorption of an appreciable portion of the aggregate for water as compared with oil may be the cause of these failures. It is felt that data secured from the "swell test" and the so-called "emulsification test" will aid in showing the suitability of the mineral aggregates for this type of construction and minimize the failures from this source. (7) Recent experimental work indicates that a heavy asphaltic oil or soft asphalt cement, cut back with a distillate such as kerosene, naphtha, a combination of both, or a suitable asphalt mixing emulsion, should be used in the mixed type in preference to the lighter oils where aggregate and moisture conditions are not highly favorable. (8) When the gravel or crushed stone road is stable and well bonded, a surface treatment, with

This View Shows a Portable Mixing Plant Recently Designed and Used for this Type of Construction. A Machine of this Type Offers Great Possibilities and it is Possible that Satisfactory Equipment of this Type will be Available in the Near Future.

a hot application material, a quick drying asphalt cut-back or a suitable asphalt emulsion, should prove more satisfactory and economical than a light oil mix treatment. A considerable mileage of light oil mix surfaces has been built in the West where conditions were more suitable for the surface treatment type. (9) Light surface treatment, to give a wear resistant mat, often may be added economically to an oil mixed surface as maintenance rather than scarifying and remixing with additional oil as is now generally done.

CHAIRMAN SKIDMORE: I am sure we all appreciate the excellent paper by Mr. Pauls. The paper will now be open for discussion and the discussion will be opened by Mr. Z. E. Sevison, state highway engineer of Wyoming.

# Mixed-in-Place Asphalt Road Construction in Western States

**By Z. E. Sevison, Cheyenne, Wyo.**
*State Highway Engineer, Wyoming State Highway Department.*

Extensive road mileage, which includes several thousand miles of constructed gravel, together with limited funds, has led to the construction of this type of "mixed-in-place" surface, as outlined by Mr. Pauls, throughout the Rocky Mountain and western states. That it is meeting with the approval of the people and is giving adequate service, is amply attested by the fact that in the past few years approximately 3,000 miles of this particular type have been built, as well as 2,000 miles of other intermediate bituminous treatment types. These figures are based on recent reports with Arizona, Oregon and Washington not reporting, so that there probably is about 4,500 miles of this type in the West. Furthermore, the prospects are for approximately 2,000 miles to be built this coming season, Wyoming and Idaho having programs for 450 to 500 miles each. Wyoming plans to treat 1550 miles in the next three years and will have 1900 miles of the low cost bituminous type by the end of 1933.

### CONSTRUCTION PRACTICE IN WYOMING.

In Wyoming the method used in the "mixed-in-place" type, essentially is that described by Mr. Pauls. It might be added, however, that the twenty-foot width has been adopted on the major part of the work, together with feather edge construction. This width, to a great extent, prevents the breaks along the shoulder so common in the narrower sections. The feather edge feature aids materially in carrying the water to the outer edges of the shoulder and thence to the ditches. The thickness that will be necessary depends largely on the amount of traffic that is to be carried. If this is sufficient to justify the expense, a three-inch section is to be recommended. However, we have treated successfully a twenty-five mile section which will not average much more than two inches. Part of this section has had about eighteen months' traffic and has stood up well, requiring but very little maintenance. On this particular section the native aggregate of sand and gravel in the grade was utilized, no surfacing material being added.

Discussion of this type is incomplete without consideration of the thickness and character of the base. Essentially, the base should provide sufficient strength to minimize surface failure due to weakness and should perform the additional function of minimizing the effect of moisture. The design of the road has a bearing on both of these functions. In Wyoming it has been our standard practice from the beginning to construct what we term an "elevated grade line". By this design the surface of the road has a general elevation above the adjacent ground of from one to two feet, thus providing excellent drainage and, primarily, a snow free road in the winter. Cuts are kept to a minimum, but where necessary they are taken out to the right-of-way line having a top width of ninety-six feet which permits wide, well drained ditches.

U. S. Route No. 20 in Wyoming. Federal Aid Project No. 107. One Mile West of Glenrock, Looking West. An Oiled Road.

A well drained elevated road-bed does not require the depth of surfacing that otherwise would be necessary and we, therefore, have constructed our "mixed-in-place" surfaces with a total compacted thickness, including base, of from four to six inches, with the six-inch as standard on heavy or gumbo soils. With the oil mat having a thickness of three inches the base course of gravel, shale or crushed stone thus usually is three inches. The twenty-five mile section above mentioned has no base course as such. Certainty design must be adapted to any particular road and any arbitrary thickness cannot be justified. The design of the surfacing section should be determined by conditions on each project.

The use of a prime coat on the base as a means of reducing the thickness of the oiled mat appears to have possibilities and more information covering its use is highly desirable, particularly as to whether the detrimental effects of moisture thereby are reduced. Rolling of the treated material has never been practised in Wyoming because it has not been clear that the additional cost was justified and for the further reason that the smoothest riding surface is secured if compaction is obtained under traffic.

Regarding the aggregate grading, it would seem that this is a field for considerable thought and study. While it is true that, under otherwise favorable conditions, excellent surfaces have been obtained by this "mixed-in-place" method, using materials that contain but very little gravel, it is believed that, due to its greater inherent stability, a material should be used that has a much higher percent of well graded angular gravel than commonly is used at present. If such a grading were adopted, it would naturally follow, as Mr. Pauls has pointed out, that a heavier bituminous material should be used for the binder, with a resultant stability and imperviousness which would be greater than otherwise would be obtainable.

### MIXING IN ONLY ONE WINDROW.

The use of this kind of material would result in a more open surface texture, but, due to the fact that less binder would be needed in the mixture, the saving thus effected could be used to apply a generous coat of cut-back asphalt seal to the surface, thus insuring its imperviousness and producing a non-skid surface. Other advantages accruing to this type then would be that the binder would be less likely to be displaced, due to the action of water, and the surface itself, due to its greater inherent stability, would resist shoving and rutting to a much greater extent than the finer graded mixtures.

Mr. Pauls has mentioned a method of mixing in two windrows. We

U. S. ROUTE NO. 87 IN WYOMING. FEDERAL AID PROJECT NO. 28-A. ONE-HALF MILE NORTH OF MARYBURG, LOOKING NORTH. AN OILED ROAD.

have found it more advantageous and economical to mix in one windrow because three blade graders, if adequately powered, will move the full windrow each trip over the road. Mention has been made also of the probability of the development of a single portable mixing machine which will pick up the aggregate from a windrow and deposit it in mixed form behind the machine ready for spreading. Such a machine will find a wide and ready use, for its obvious advantages are many. It largely will eliminate interference with traffic because it can be operated to one side of the center of the road. It will reduce by more than one-half the investment in equipment for the job, will reduce many of the delays due to rainy weather and should simplify the field control. We are anxiously waiting for the successful machine of this type.

The tests as outlined by Mr. Pauls for the determination of the suitability of the aggregate are indeed of much interest and value. Guess work in this type of construction is costly, just as it is in any other line, and tests and investigations that give assurance of success in advance of construction are surely worthy of considerable thought and study. Work along these lines is being carried on in the Wyoming laboratory at the present time. The Frickstad-McKesson formula, increased by 40 per cent, has been used as a guide for the amount of oil necessary. This is corrected in the field when, in the judgment of the engineer, the mix is too rich or too lean. Considerable care should be exercised in making these adjustments as the margin of safety either way is limited. The average amount of oil applied in Wyoming for the past season on one and one half million square yards of surface was 1.67 gallons per square yard.

Most of our "mixed-in-place" type has been constructed by using the 60 to 70 grade of oil, with a specific viscosity (Engler at 122° F) of approximately 50. However, during the past season, oil was purchased from two new sources, one of which furnished an oil having an asphaltic content of 77 and a viscosity of 70, and the other having an asphaltic content of 68 and a viscosity of 35. While no appreciable difference in the behavior of these oils has been noticed as yet, it would seem that the tendency should be towards an oil with both a higher asphaltic content and a higher viscosity in order to promote stability and retard the detrimental action of moisture as suggested by Mr. Pauls. Wyoming specifications for 1931 will provide for an asphaltic content of 65 to 75 with a corresponding viscosity, Engler, of 50 to 75.

### Construction and Maintenance Costs.

The high penetration asphalt, cut back with kerosene to promote slow drying, should meet just these conditions. This, of course, is assuming that the flexibility of the surface is not destroyed. In other words, the surface should not set up so hard that it would be impossible to scarify and re-mix should this become necessary from any cause. These surfaces can hardly be considered as high type ones and it is to be expected that considerable maintenance will be required. The fact that the present type permits of being scarified and relaid readily, is of considerable importance, especially on the secondary highways. On main roads, however, surface failures might better be remedied by light surface treatments or by the multiple lift as used in Oregon. The possibility of loss of the coarser particles of aggregate due to loosening under traffic, as has been mentioned, can be overcome successfully by the application of a seal coat of cut-back asphalt of about one-tenth of a gallon per square yard. This, however, is not an argument for the use of the coarser aggregate because experience has shown that the maximum should all pass a one-inch circular opening.

Costs in Wyoming for the past season have approximated $1,750 per mile for this type of work, this, of course, being exclusive of the aggregate. Maintenance cost on 138 miles of "mixed-in-place" surfaces constructed prior to 1930 has been $275 per mile, while the cost of maintaining the untreated gravel roads during the same period has been $313 per mile. The replacement cost of the gravel aggregate, however, is $300 per mile and the total saving in maintenance costs, therefore, is $338 per mile.

U. S. Route No. 116 in Wyoming. Federal Aid Project No. 200-A. Five and Eight-Tenths Miles West of the Eastern End of the Project, Looking West. An Oiled Road Constructed in 1930.

The fact that gravel losses practically are eliminated, while at the same time a smooth, dustless surface is provided, certainly justifies the existence and continuance of this type of surface. Methods and materials as well as specifications should be adapted to meet conditions as they exist on each project or section of road. Too narrow a specification on bituminous material may not correspond with the sources of supply. An arbitrary design may be uneconomical for the traffic and may prevent the use of local materials that are really suitable.

Our experience in Wyoming amply justifies the program of 1,900 miles mentioned above and we strongly are of the opinion that our adjoining states might well adopt this type of improvement for large mileages and thus provide their people with a dustless, mudless surface that is the smoothest riding one that can be built and that is so well adapted, through low cost, where funds are limited, to providing the highway for high speed that now generally is demanded and expected by the motoring public.

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CHAIRMAN SKIDMORE: Gentlemen, notwithstanding the fact that we have a day and a half's work to do, this is a subject on which we would like to entertain discussion from the floor. If any one has anything to say on this subject, he is now welcome to say it. We will hear from Mr. Walter Heimbuecher, city engineer of University City, Mo.

# Use of Retread Asphalt in Resurfacing Worn Out Concrete

## By Walter Heimbuecher, University City, Mo.

*City Engineer, Municipality of University City.*

University City is a residential suburb adjacent to the City of St. Louis. Olive Street road, an old county highway through our city and a major thoroughfare from the industrial district, carrying a heavy volume of heavy truck traffic, was paved with concrete in 1922. The pavement was laid, forty feet between curbs, with a one-half inch transverse expansion joint every thirty-three feet and no center contraction joint. This was prior to development of the idea of having dowels at all joints and, as a consequence, some four years ago the pavement began to sink at the joints. Due to the impact of heavy trucks this pavement sank from three-quarters of an inch to as much as two and one-half inches, resulting in a very rough riding pavement for passenger cars. A year ago we brought these low areas up to grade by painting the concrete with an emulsified asphalt on both sides of the joint for a distance of four to six feet, filling over it with a rock asphalt, striking off with a ten foot straight-edge and rolling in place. While this remedied the situation somewhat, the pavement still was uneven as it developed irregularities in quite a number of places other than at the joints. As an experiment we tried the "mixed-in-place," "retread" method during this past season.

### METHOD OF LAYING RETREAD SURFACING.

A line was marked seven feet from the curb on each side so that we would have twenty-six feet of actual resurfacing. We felt that it was unnecessary to resurface the seven-foot strip adjacent to the curbs since that was used for parking. A prime coat of one-half gallon per square yard of an asphalt emulsion first was applied to act as a tack coat for holding the "retread" to the concrete. The stone next was applied at the rate of about fifty pounds per square yard and then a 50 per cent naphtha cut-back Bermudez asphalt was applied at the rate of about one-third of a gallon per square yard. The mixing blader then was put in operation and the stone and asphalt were mixed in place, the mixture being struck off on the final passage of the mixing machine. About three rounds of the machine was all that was necessary. A light sprinkle of three-eighths-inch stone chips, at about ten to twelve pounds to the square yard, was applied. The entire surface was rolled and traffic was permitted to run on it for a period of two weeks, after which a seal coat of liquid asphalt of about 165 penetration was applied at the rate of one-quarter gallon per square yard. Then more stone chips were scattered over the surface. The stone used was an imported traprock from southern Missouri, very tough, and with a hardness of 16 and a French coefficient of 16. It cost us $3.30 per ton on the cars at our railroad siding one-half mile from the work. The cost of unloading, hauling and spreading, which was done by the city forces, is included in the labor cost given below. Labor was paid 50 cents per hour and the foreman 75 cents per hour. The time of the city's roller was charged against the job at $20 per day and that of the city trucks at $12 per day. The asphalt was applied by a commercial distributing company and was paid for at a fixed rate per gallon applied. The total number of square yards in the improvement were 5,030 and the cost of this "retread" job was 41.9 cents per square yard. Cost and material items were as follows:

*Cost*

| | | |
|---|---|---|
| Labor | $288.75 | |
| Roller, 4 days | 80.00 | |
| Trucks, 21-1/8 days | 253.50 | |
| Asphalt, 4,025 gallons | 786.38 | |
| Trap Rock, 212 tons | 699.60 | |
| | Total | $2,108.23 |

*Material*

| | |
|---|---|
| Asphalt primer | .228 gallon per square yard. |
| Cutback asphalt | .333 " " " " |
| Liquid asphalt, seal coat | .238 " " " " |
| Traprock | 84 pounds per square yard. |

Before starting this work, we ran a home-made "bump-meter" along the center line, along a line ten feet north, and along a line ten feet south of the center line. We recorded the number of depressions or elevations of one-half inch or more and then ran the same machine over the work along the same lines after the surface had been under traffic for two months. A description of the "bump-meter" may not be out of place at this time.

### Testing the Smoothness of the Surface.

The "bump-meter" is simply an "A" frame of light three-quarter-inch tubular steel, ten feet long with small rubber-tired wheels at each end and having a small steel wheel, movable in a vertical plane, mounted at the center. Two dry batteries are attached to the frame and to a bell, and a double electric contact is attached to the axle of the movable wheel, so that when the "bump-meter" is run over a pavement and a depression, one-half inch or more below a straight line connecting the rubber-tired wheels is encountered, the movable wheel drops, closes the lower contact and rings the bell. Similarly, if an elevation one-half inch or greater, above a straight line connecting the rubber tire wheels, is encountered the movable wheel closes the upper contact and causes the bell to ring.

The covering of the "retread" averaged about three-quarters of an inch in thickness and removed more than 50 per cent of the depressions and elevations. The probabilities are that another "retread" surfacing of the same thickness would reduce the number of irregularities still more. The "bump-meter" readings for the tests related above were as follows:

"BUMP-METER" READINGS.

| | Before Retread | | After Retread | |
|---|---|---|---|---|
| | High | Low | High | Low |
| Ten feet south of center line | 46 | 48 | 26 | 25 |
| Center line | 51 | 50 | 22 | 23 |
| Ten feet north of center line | 49 | 47 | 22 | 21 |
| TOTAL | 291 | | 139 | |

We also put down another short piece about 500 feet long, using this "retread" work, but this was really a penetration job and not a "mixed-in-place one. The old concrete pavement first was primed with an asphalt emulsion at the rate of two-tenths of a gallon per square yard and then one-half inch of traprock was applied at the rate of about 40 pounds per square yard. This was smoothed with a road grader, the final smoothing being made with a home-made contraption of twelve street-brooms fastened to a frame made of two-by-fours and drawn by a light truck. The stone next was rolled once and penetrated by means of a power distributor with thirty-five hundredths of a gallon of emulsified asphalt. It then was left to set for about two hours. Another layer of the same sized traprock, at approximately 40 pounds to the square yard, was applied and bladed, "broom-dragged" and rolled once. Then another thirty-five hundredths of a gallon of emulsified asphalt was applied. The surface next was covered with about ten pounds of a smaller traprock, ranging in size from one-quarter inch down to dust. Then it was "broom-dragged" and rolled until the mix had set. The cost of this work was:

| | |
|---|---|
| Labor | $57.75 |
| Roller | 45.00 |
| Trucks | 25.50 |
| Asphalt | 180.00 |
| Traprock, 68 tons @ $3.45 | 234.60 |
| | $542.85 |

| | |
|---|---|
| Square yards in improvement | 1,389 |
| Cost per square yard | $.398 |
| Asphalt used per square yard | 1.08 gallons |
| Traprock used per square yard | 97.8 pounds |

Up to the present time both of these "retread" jobs have given very satisfactory service. The users of the road are much pleased with its smoothness. However, I am withholding judgment as to its durability and serviceability until it has gone through a winter of snow, sleet, ice and skid chains. I will probably be in a position a year from now to give a more detailed report on the results of this experimental section of pavement.

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CHAIRMAN SKIDMORE: Since there is no discussion from the floor we will proceed with the next paper, that of "Employment of Asphaltic Materials in Mixed-in-Place Types," by Mr. H. J. Spelman, chief engineer of the State Road Commission of West Virginia.

# Employment of Asphaltic Materials in Mixed-in-Place Types

**By H. J. Spelman, Charleston, W. Va.**
*Chief Engineer, West Virginia State Road Commission*

"Mixed-in-place" construction is a new type evolved in the last few years and made possible by the development of heavy tractor grading and hauling equipment. The type of construction probably was evolved from efforts that were made to drag surface treatments in order to make them smoother. Various names have been given to this type of construction such as "retread," "oil processed roads" and "heavy surface treatments."

Obviously there is a wide variation in this type of construction both as to the thicknesses and the materials used. This variation extends from the lower limit of what is not much more than a dragged surface treatment only a fraction of an inch in thickness, to the upper limit of what is virtually an asphaltic concrete wearing surface from two to two and one-half inches in compacted thickness. The range for this type of construction then, will run from the surface treatment, or the "mat" or "carpet coat" discussed by Mr. Weathers, to the "cold premix types" to be discussed by Mr. Mullen. The lines between them are indistinct, so my discussion may at times overlap both of theirs. Some definition is desirable, particularly to mark the line between "dragged surface treatments" and "mixed-in-place" construction. A number of states, my own included, are now requiring all surface treatments to be dragged. A suitable differentiation would be to call any work that

"Mixed-in-Place" Construction. Any Well Stabilized Surface may be Used as a Foundation for this Type of Surface. This View is of a Sandstone Base After a Year's Traffic. Note its Uneven Condition. West Virginia State Highway Department.

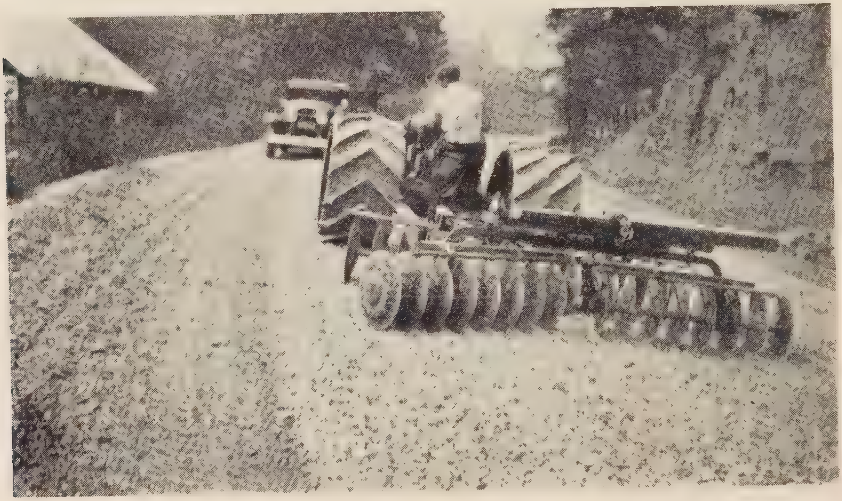
requires only dragging and rolling a "surface treatment," and any work that requires the use of grader blades or disc harrows, or both, "mixed-in-place" or "retread" construction.

"Mixed-in-Place" Construction. Clean Crushed Stone or Gravel is Spread from Trucks to a Depth of About Two and One-Half Inches, Loose. West Virginia State Highway Department.

The "premix" type is very closely matched by the experimental development reported by Mr. Bert Myers, materials engineer of the Iowa Highway Department, of a machine to pick up loose aggregate materials on the roadside, run them through a continuous mixer where they

"Mixed-in-Place" Construction. Additional Spreading is Done by Means of a Grader. West Virginia State Highway Department.

of this paper, is that "mixed-in-place" construction is that type which is are coated thoroughly with heated asphaltic materials in the proper proportions and discharge them upon the roadway ready for spreading. Again a definition is needed, and the one I have adopted for the purpose mixed upon the surface of the road and any type that involves mixing the aggregates and bituminous material in a mixer belongs in the "pre-mix" group.



"Mixed-in-Place" Construction. A "Discer" is Run Through the Base Several Times in Order to Insure Even Grading. West Virginia State Highway Department.

## TYPES OF MIXED-IN-PLACE CONSTRUCTION.

The "mixed-in-place" type may be divided into two groups, in respect to the source of aggregates, namely "mulch treatments" and "retreads." "Mulch treatments," as I define them, are those involving the treatment of aggregates in the form of a mulch already on the road-bed surface. "Retreads" are those treatments where the existing surface or base is swept clean of all loose materials. For "retreads" the clean surface of the road-bed is primed with bituminous material before applying the aggregate. For "mulch treatment" the loose material is shot directly with bituminous material without first priming the underlying hard, compacted material.

The "mulch" type may also be divided into two more groups as to the character of aggregates; one being the mulch of gravel or crushed stone free or almost free of any material under ¼ inch in size, and the other being the mulch of gravel and sand with a considerable quantity of material less than ¼ inch in size. This latter type will produce a sand asphalt or a closed type of mix similar to sheet asphalt or asphaltic concrete such as the so-called "Topeka mix," depending upon how little or how much material over ¼ inch is in the aggregate. The first "mulch" group and the so-called "retread" will produce a surface similar to the mixed bituminous macadam or cold patch, or as it is sometimes called the "open mix type."

### Advantages of Mixed-in-Place Construction.

The definite advantage of "mixed-in-place" construction, over the earlier types of similar surfaces mentioned above, is that it can be and is constructed in many instances so as to produce much smoother riding than any other type of bituminous surface. This development is of the greatest importance because of the doubling of the speed during the past ten years of all of the motor vehicles traveling over roads. This smoothness of the riding surface is produced by the heavy equipment now available for blading and dragging this "mixed-in-place" work.

"Mixed-in-Place" Construction. The Distributor is Serviced from Trailer Tanks, thus Keeping the Outfit Continuously at Work and in Better Condition. West Virginia State Highway Department.

An additional and apparent advantage of "mixed-in-place" construction, over these same earlier types, is its cheapness of construction. "Mixed-in-place" construction can be built at less than half the cost per square yard of any of these earlier types. I call this an apparent advantage because our experience with "mixed-in-place" construction has not yet extended over a sufficient number of years to indicate the life of such surfaces as compared with those of the earlier types.

### Scope of Construction and Uses.

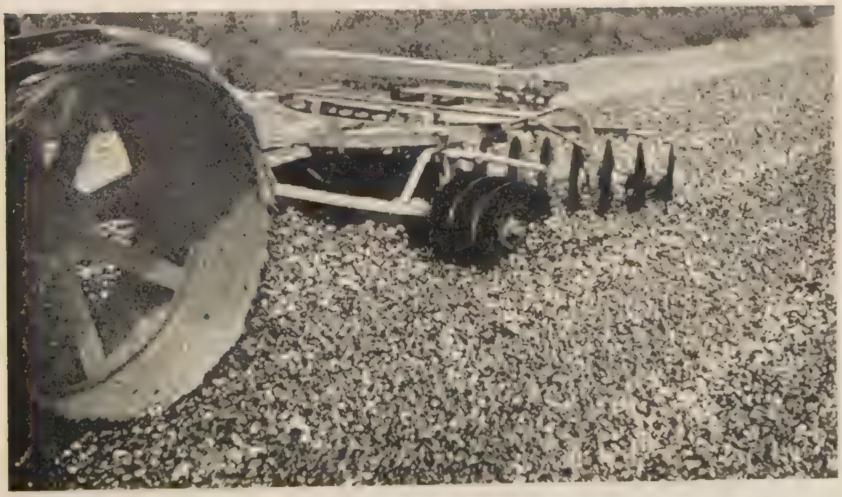
No figures are available, or at least I have been unable to obtain any, of the number of miles of this "mixed-in-place" construction that have been built in this country to date. Unquestionably tens of thousands of miles have been produced and the growth will continue to be rapid, for the usefulness of the type extends over a wide range. On the dusty gravel and crushed stone roads of low construction cost and with maintenance costs increasing all out of proportion to the traffic increase, this type of construction has been used successfully to produce extremely smooth, dustless, riding surfaces, fully equal from the standpoint of traffic to the best asphaltic types. Old worn waterbound macadams have been rehabilitated as smooth modern type roads at a very low cost by this "mixed-in-place" or "retread" construction. Rough penetration macadam surfaces, the despair of the maintenance engineers for years, have been made comfortable and good riding surfaces by the use of "retread," sometimes almost amazingly thin. And now, as a late development in my own state, comes the use of this "retread" or "mixed-in-place" construction as a top course placed on crushed or knapped broken stone bases at half the cost of any other type of bituminous surface we hitherto have used.

"Mixed-in-Place" Construction. Applying the First Application of Cut-Back Asphalt. West Virginia State Highway Department.

### Review of Mixed-in-Place Construction.

"Mixed-in-place" construction has now been used in so many states and counties, and under such widely varied conditions, that it obviously will be impossible even to mention all of them and it will be necessary to limit the descriptions of those mentioned. As far as can be learned the first "mixed-in-place" construction was done in 1923 by Wisconsin on gravel roads. California and Oregon have constructed considerable mileages of "oil processed" roads or "mixed-in-place" construction since 1926. This construction has been applied to gravel and crushed stone roads. It has been what I call the "mulch construction," the aggregates being either loose on the surface of the road, or the road surface being scarified to a sufficient depth to obtain the aggregates. Excellent descriptions of this work have been printed in the technical press from time to time. Others of the western states have done similar work. New Mexico recently adopted similar methods and, up to the first of this year, has constructed 300 miles of "oil processed" roads at an average cost of about $2,100 per mile. The rate of application of the bituminous material varied on this work from 1¼ gallons to 2¼ gallons per square yard. The roadway materials were sandy gravels. This work is well described in a bulletin issued this year by the New Mexico Highway Department. The Ohio Highway Department has provided "mixed-in-place" construction by the "mulch treatment" method to quite a mileage of gravel roads. The Missouri Highway Department has used both the "mulch" and "retread" type of "mixed-in-place" construction and the work was excellently described by Chief Engineer Cutler in a paper before the American Association of State Highway Officials in November, 1929.

"Mixed-in-Place" Construction. Close-Up View of Application of the First Cut-Back Asphalt. West Virginia State Highway Department.



"Mixed-in-Place" Construction. The Stone and Asphalt are Thoroughly Mixed by Discing as well as by Grader and Drag Manipulation. West Virginia State Highway Department.

### EXCELLENT RESULTS WITH RETREAD IN INDIANA.

A review of "retread" construction would not be complete without mention of the work done in Indiana under Maintenance Engineer Hinkle. Very complete specifications have been worked out for the various thicknesses of construction, the quantity of bituminous material and the maximum size of the stone or aggregate used, increasing with the thickness of the construction. Excellent riding surfaces have been obtained. In Missouri, Mr. C. P. Owens, state maintenance engineer, reports the use of finely ground flint aggregate, mixed with stone and cut-back asphalt, to produce a "mixed-in-place" construction. In Macomb County, Michigan, County Engineer Leon Luke reports resurfacing gravel roads with an asphaltic mixture produced at county owned gravel pits. The Tennessee Highway Department is constructing from 350 to 400 miles annually of a "mixed-in-place," or "retread" type and now has about 1,600 miles of this type, which has been placed on gravel, chert or traffic-bound stone bases at an average cost of 30 cents per square yard. This work has taken about three-quarters of a gallon of bituminous material and about 80 pounds of crushed stone or gravel, ranging in size from one-quarter inch to one and one-quarter inches. The South Carolina Highway Department has done some "mixed-in-place" construction on top soil roads, which is described in an excellent paper in the magazine *Public Roads* for November, 1927, by Mr. Pauls. Many other states and counties might be mentioned, but time will not permit.

### GRADES OF BITUMINOUS MATERIALS.

It is proper to state here that there is a difference between the so-called "oil processed" or "mulch type" construction and the "retread" type and it should be kept in mind when comparing the costs. In the "mulch type" or "oil processed type," as used by New Mexico and other far western states, the aggregates are already in the roadway and the

"MIXED-IN-PLACE" CONSTRUCTION. MULTIPLE BLADE DRAGS ARE A GREAT HELP IN SECURING THOROUGH MIXING. WEST VIRGINIA STATE HIGHWAY DEPARTMENT.

"Mixed-in-Place" Construction. Final Smoothing with a Multiple Blade Drag having a Long Wheel-Base Gives an Extraordinarily Smooth Surface. West Virginia State Highway Department.

costs generally given do not include any allowance for aggregates, whereas in the "retread" type, the roadway surface first is swept and primed, aggregates then are delivered upon it and bituminous material is applied, so that the cost of aggregates is included in the costs given for this type.

No attempt will be made to give detailed specifications for the different types of bituminous materials used in "mixed-in-place" construction. On the Pacific Coast the so-called fuel oils or the various grades of road oil have been used for the "oil processed" roads. In the East for the "retread" construction a cut-back asphalt has been used.

### Mixed-in-Place Construction in West Virginia

During the past season there have been built in West Virginia 164 miles of "mixed-in-place" top course, ranging from thin resurfacings for smoothing rough macadam, to two-inch top courses constructed on knapped or crushed stone bases. The cost of this work totalled approximately $1,000,000. Of this mileage, 115 miles were built under contract and the balance was done by the state forces. The bases on which this type of top was constructed included native gravel, Ohio River gravel, crushed stone, knapped stone, traffic-bound stone, bituminous macadam and brick. The widths of construction varied from 16 to 20 feet. For aggregates crushed gravel, crushed stone and crushed slag have been used. The size called for is from one-half inch to one and one-half inches for the construction work, but for thin resurfacings of old macadam we have used material from one-quarter to three-quarters of an inch in size. Cut-back asphalt has been used with excellent results.

One of the most promising possibilities that we see for this "retread" or "mixed-in-place" construction is in the widening of old roads. In West Virginia we have a good many miles of sixteen-foot macadam. In fact we did not, until this year, definitely adopt a minimum width of

"Mixed-in-Place" Construction. As the Asphalt Sets Up After the Second Application, the Surface is Smoothed Out Either with a Drag or a Grader Blade. West Virginia State Highway Department.

eighteen feet of surfacing on the state roads. These older sixteen-foot roads were built with what seems today to be an excessive crown. Settlements have occurred in spots and the surfaces are not smooth riding ones. This year we have let contracts for widening five miles of sixteen-foot macadam to twenty feet, providing for the construction either of two feet of crushed stone base on each side or four feet on one side, building this base up somewhat above the level of the edge of the old road and then constructing a "retread" over the entire surface. This has given us a splendid, smooth riding twenty-foot roadway. Under a similar form of construction an old nine-foot pavement was widened to eighteen feet. The results obtained with this work, particularly with widening the sixteen-foot pavement have been so satisfactory that we will undoubtedly do much more of it next season. It provides a low cost solution of our troubles with the sixteen-foot macadams near the large population centers and the work can be rapidly completed.

### Use of Retread for Leveling Rough Roads.

Another very valuable use we have found for this "mixed-in-place" or "retread" construction has been in the smoothing up of rough bituminous macadam roads. Some of our bituminous macadam roads were built on the knapped stone base, similar to the old sub-base construction, and were not originally built particularly smooth. This did not matter when average traffic speeds were from twenty to twenty-five miles per hour, but with the doubling of these speeds it has become important. During the past season this "mixed-in-place" has been used for resurfacing most of these roads and during the coming season we expect to resurface any others that are not smooth riding, so that the end of 1931 should see the last of any "rough riding" roads on the state road system.

On all of our construction this year we have provided for cleaning and priming the surface of the existing road or base. The bituminous macadams, of course, do not take much cleaning but the gravel and stone bases take a pretty thorough sweeping. The prime varies of course. On bituminous macadam as little as one-sixteenth of a gallon per square yard is satisfactory, while the knapped or crushed stone bases will require from one-third to one-half gallon per square yard. Except for the cleaning and priming the methods are the same on all of this work. I will describe briefly one contract that is typical of the construction methods used. It is twenty-six miles long and has a knapped sandstone base for twenty miles and an Ohio River gravel base for six miles. The "mixed-in-place" top on this job was laid during the past season by one contractor. This particular outfit built forty miles during 1930 for the state.

### MIXING METHOD USED ON A WEST VIRGINIA ROAD.

The knapped stone base was swept thoroughly with a big circular sweeper drawn by a truck. As fast as this sweeping was completed, dirty spots were cleaned by hand with wire brooms. The prime coat then was applied. The first application of prime, at a rate of one quarter of a gallon per square yard, was applied over most of the job before any of the top course proper was started. All of the material had to be hauled over one end and it was found that applying the prime in advance helped guard against any deterioration of the base under traffic and did little or no injury to the primed base. A second application of prime at the rate of one-tenth of a gallon per square yard was applied just before spreading the gravel in order to freshen the primed base. No cover was used with the prime.

The aggregate for this job was Ohio River gravel, the specifications requiring at least 60 per cent to be crushed, and the gravel ranging in size from one-half to one and one-half inches. After priming, this material was dumped from trucks and spread with mechanical spreaders to a

"MIXED-IN-PLACE" CONSTRUCTION. THOROUGHLY MIXED, SMOOTHED OUT AND READY FOR ROLLING. WEST VIRGINIA STATE HIGHWAY DEPARTMENT.

thickness of about two and one-quarter inches uniformly over the road. Traffic was permitted to travel through this until just prior to the first application of asphalt, when the crushed gravel was smoothed up with a twelve-foot blade drawn by a ten-ton tractor and the asphalt immediately applied at a rate of one-half gallon per square yard. This then was thoroughly mixed by successive trips of a disc harrow, after which it was windrowed by the twelve-foot blade to the center, turned back and smoothed down. The second application of asphalt at a rate of approximately 0.55 of a gallon per square yard then was applied. It again was mixed thoroughly by the disc harrow and turned over several times by the blade, after which it was smoothed down over the entire surface and dragged continuously by a drag hauled by a ten-ton tractor until it set up. When it had set sufficiently it was rolled thoroughly with a ten-ton roller. The roller was equipped with lights and was used all night long. After the completion of the entire section, a light application of one-quarter by three-quarter-inch gravel chips was spread over the surface of the road at the rate of about twenty pounds per square yard. The seal application of asphalt at the rate of .35 of a gallon per square yard then was applied. This treatment was dragged thoroughly by the big drag and then rolled.

"MIXED-IN-PLACE" CONSTRUCTION. THOROUGHLY COMPACTING BY ROLLING THE SURFACE.
WEST VIRGINIA STATE HIGHWAY DEPARTMENT.

Some tendency to pick up in a few spots under traffic occurred on this job, as it does on this type of construction generally, but these places were patched with gravel chips and applications of the same cut-back material. The road was not closed to traffic at any time during any of the operations. It was found necessary, though, to provide for one way traffic with a watchman at each end, at the sections where the bituminous material was being spread and where the blading was being done.

On this particular job both the bituminous material and the gravel had to be hauled an average distance of eighteen miles, the maximum haul being thirty-one miles and the minimum haul five miles. The unit prices for this job were as follows: asphalt per gallon, 12.5 cents; gravel per ton, $3.85; cleaning old surface, per square yard, 1 cent. The cost per mile of the eighteen-foot surface, including quite a number of widened curves was $6,840 and the cost per square yard was 57 cents. These figures are based upon the final estimates but do not include engineering and inspection. Because of the long haul this cost was higher than other similar work done during the year but was less than half the estimated cost of a penetration macadam surface. The completed road compares favorably in riding qualities with any we have ever built and is superior in this regard to our former penetration and surface treated macadams.

### USE OF DISC HARROW A NEW FEATURE

The use of the disc harrow is a new feature tried out on this year's work. It apparently provides for a more thorough mixture of the asphalt and aggregates than the constant turning by the road machine blade. It was not called for in the specifications for the year's work but is now being incorporated in our specifications because of this year's experience. It reduces the amount of turning to be done with the blade and accomplishes the same purpose more thoroughly and at no greater expense. Another new feature adopted by the contractor on this particular job was the placing of wheels on the drag. The type of drag used heretofore was difficult to turn, messed up the surface badly when turned and dragged dirt on to the pavement when it was being hauled in and off of the shoulders. With the wheel rig adopted, the drag can be swung up and on to the wheels, turned around easily and then let down.

"MIXED-IN-PLACE" CONSTRUCTION. THE FINISHED SURFACE. NOTE THE TEXTURE WHICH AFFORDS THE NON-SKID AND SMOOTH RIDING QUALITIES SO MUCH DESIRED. WEST VIRGINIA STATE HIGHWAY DEPARTMENT.

For good results with this type of construction, the quantities of both the aggregates and the bituminous materials have to be varied, depending upon the smoothness of the base upon which it is placed. It is also important to leave on the job when it is completed a quantity of chips and bituminous materials for the immediate patching at the smallest sign of ravelling that may develop. The maintenance forces should follow the completion of the job very closely. The pictures show clearly the various stages of the construction and the various operations.

CHAIRMAN SKIDMORE: We have here on the platform several gentlemen of national and international renown and I will ask Mr. Leroy M. Law of St. Louis, president of The Asphalt Institute, to present them to you.

PRESIDENT LEROY M. LAW: Gentlemen, it has been our pleasure to have been here for the last two or three days discussing problems relating to the earth, but there are also problems pertaining to the air. Those celestial vehicles which we call airplanes cannot begin or end their flights without airports. We have three gentlemen here who are helping us with our airport problems and who, I think, you will all be glad to hear. I take great pleasure in introducing to you Captain Frank M. Hawks, superintendent of aviation for The Texas Company, whose sensational landing, after his record flight here from New York—1090 miles in six hours or so—we all witnessed yesterday at the Memphis Municipal Airport. Captain Hawks holds more cross-country speed records at the present time than any other aviator. And we are glad to have with us Major Jimmy Doolittle, the noted former American army ace, Schneider cup winner and cross-country speed-record holder who came here this morning by airplane in less than two hours from St. Louis. He is in charge of aviation matters for the Shell Company. And last, but by no means least, we present Colonel John H. Jouett, noted World War ace, late of the United States Army Air Service and commandant of important army aviation posts, new superintendent of aviation for the Standard Oil Company of Louisiana, who also flew to this meeting in record time from New Orleans.

CHAIRMAN SKIDMORE: Gentlemen, we are now going to turn aside from the regular program and Captain Hawks is going to tell us something about his conception of adequate airport surfacing. I present Captain Hawks.

# An Aviator's Conception of Adequate Airport Surfacing

## By Captain Frank M. Hawks, New York, N. Y.

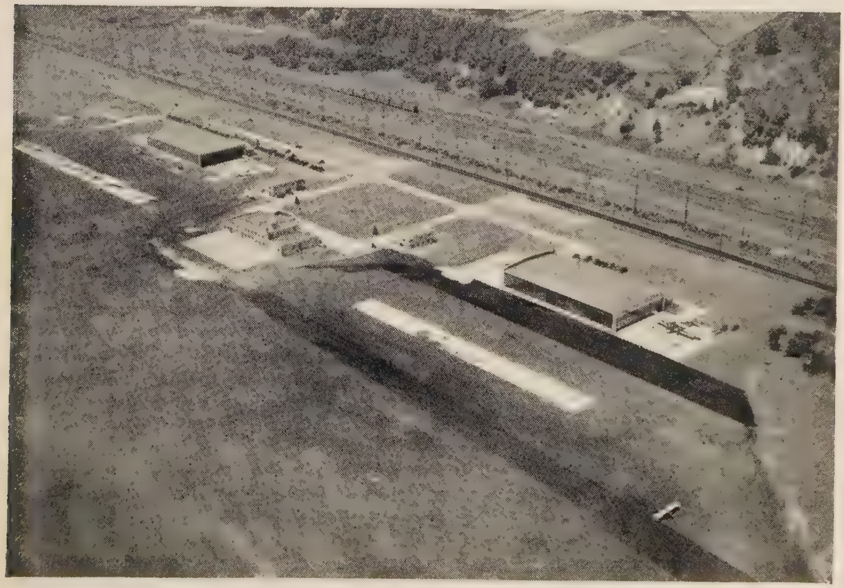
*Superintendent of Aviation for The Texas Company*

This is the first time that I have ever read a paper before a meeting and I hope you will bear with me. I am accustomed to talking extemporaneously, as poor as it may be, but that has been my way of doing it. I was asked to make, however, a few remarks about yesterday's little trip, since perhaps the high lights as to that would not be so drab as the other remarks I have set down. The trip, of course, was made especially to attend this meeting and to have the pleasure of presenting to you gentlemen my conception of asphalt surfacing for airports. I left New York at eleven o'clock, A.M., your time, and, as you know, came in here about 4:35 P.M., your time.

Several questions have been asked concerning the nature of the day, the poor visibility and the bad flying conditions. There was not any such thing as that at all. The trip was very pleasant, except that there were a lot of head winds and, consequently, it was not possible to accomplish the distance in as good time as I had hoped. The day was perfect, in fact, with an unlimited ceiling and very fine visibility. I do not think I ever will fly to Memphis again on a straight line from New York because, though I knew West Virginia was a rough country, I did not know it was quite as rough as it was yesterday and it lasted so long. There are a lot of landing fields in West Virginia but they all seem to stand on end and I was rather glad to get down around Nashville where flying and possible landing conditions were much better. I used to think that Tennessee was bad but when I reached the vicinity of Nashville I saw a number of places to land, especially along the river bottoms. From then on until I reached Memphis I found that the nature of the country was not nearly as bad as it had been in West Virginia in the earlier part of the day.

### SMOOTH AND ROUGH LANDING AREAS

I have been asked to give my opinion as an aviator on the possibilities and merits of asphalt in the development of airports. Now, as an aviator, I am much more interested in flying than I am in the construction of a base port. Aside from the experience one obtains while learning or acting as a training pilot at an airport and in such capacity repeatedly landing and taking off from the same runway or set of runways, one obtains little or no intimate knowledge of the actual construction of the runways at any particular airport, other than knowledge as to whether they are



KINGS COUNTY AIRPORT, SEATTLE WASH. KNOWN AS BOEING FIELD. SHOWING BITUMINOUS, SLAG-SURFACED LANDING AREA.

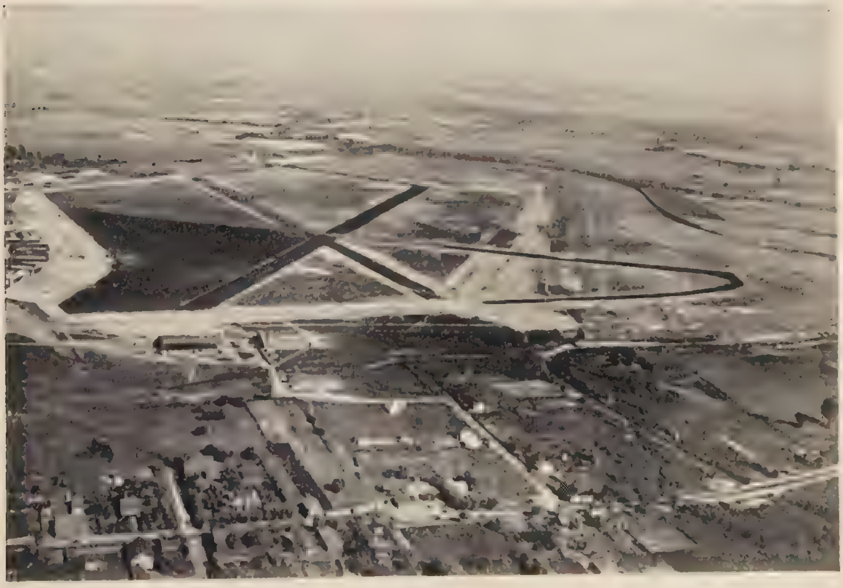
smooth or rough or good or bad. In fact, our principal interest in them is from the impression we get, while we are at any particular port, as to the care given the ship and the ease and safety of landing and taking off. Airplanes now are built to land at very high speed. Training planes, however, land at much slower speed. The landing and take-off areas must be such that both these types of planes, as well as the heavy transport planes, can be accommodated. In taking off or landing, three points of contact are normal for light planes—the two wheels of the landing gear and the tailskid or prop. As to these, the main impression would be as to what type of surface would be most satisfactory for two soft and one hard contact points, either on leaving or arriving at the port.

### Dust Raised by the Propellers

Taking the port as a whole, the pilot primarily thinks of it in two ways. First, as to the care of the ship when in the port and second, as to the ease and safety of taking off or landing. The controlling features, to my mind, in the second instance are the character of the runway surface, and in the first, aside from the mechanical and storage facilities, the general cleanliness and upkeep of the field in general. Personally I know little about the actual methods or the details of construction and the relative cost of the various types of landing fields or runways. I am aware, however, that the amount of money available greatly influences the type of construction possible and the estimated income from any particular port governs the amount originally to be spent in the development of the airport site. I will, however, point out to the best of my ability what final characteristics should most appeal to me if the money were judiciously expended.

Let us take up first the care of the ships while in the port. Whenever the engine of a ship is in motion the propeller is rotating and creating a back draft which varies with the speed of the propeller. You will appreciate that with a 400 horse-power, or even a higher horse-power engine, a tremendous amount of energy is being put into the air and is passing back, over and parallel to the ground. This energy undoubtedly will move any objects which are loose. Particularly does it move the surface of the ground if that is not well knitted together. This means, wherever the ships are warmed up or the engines are tested out, that the immediate vicinity must be paved or surfaced in some manner so that no dust or material is thrown up by the propeller action. Of course, most of this part of the work is localized so that the necessary warming-up platforms and taxi-ways, which are the intercommunicating lines of the airport, can be taken care of on a smaller scale than the rest of the port. The balance of the area, however,—the field at large as well as the runway—requires greater consideration. If the surface of the field is of loose earth material, any considerable breeze will create clouds of dust that have a bad effect not only on the ships but on the personnel and, of course, on visitors at the port. Dust blowing from the field to the warming-up platforms or even into the hangar, will penetrate the air that is taken into the manifolds and the carburetor of the motor. Eventually this dust may assist in stopping up the oil passages in the motor and will coat all exposed surfaces of the ship.

Various means have been tried, I understand, to lay this dust. Some are better than others, or at least they seem to have a more lasting effect. However, the only real satisfactory dust-layer will be one that not only coats the dust and makes it bind together but that sticks it together and to the ground so tight that it is not disturbed by the back wash from the propellors of the larger motors. If the dust only is coated lightly and can be moved by the propellor blast, its effect on the planes is worse than the uncoated dust. It sticks and is difficult to remove, either from the exterior or the interior surface. Therefore, I believe that dust-laying, for the major part of the field, is necessary and the amount of asphalt material used should be sufficient to give a semi-permanent effect. I appreciate that this would involve considerable expense initially but, in the long run, it probably will be no more expensive than not to do it.



LAMBERT FIELD, ST. LOUIS, MO. SHOWING BITUMINOUS RUNWAYS AND LANDING AREA.

### ARTIFICIAL RUNWAYS SOMETIMES NECESSARY

Taking up the question of the runway, the most generally satisfactory type of surface is a well-knitted, deep-rooted turf. It has firmness without being rigid and roughness without being harsh. It is a known fact that in certain sections of the country and in certain types of soils it is impossible to raise satisfactory turf. In other localities where it is possible to develop the turf, its actual condition at any moment is dependent on the weather conditions. The turf will deteriorate and dry out rapidly in drought, while with excessive rain or when frost is leaving the ground it will become soft and mushy and will cut up readily under heavy traffic conditions. In some ports, of course, the amount of traffic is so great, or would be so great, on certain sections, that the maintenance of a satisfactory turf would be prohibitive. It, therefore, is necessary and expedient on the more important landing fields to construct, over at least a portion of the field, artificial runways other than turf or natural soil. These artificially constructed strips, aside from their dimensions, which are specified by Department of Commerce regulations, as far as possible should have a surface as much like turf as it is possible to contrive mechanically. Lack of funds may prevent building up to the desired extent the first year but in such cases the character of the surface should be such that it easily can be strengthened or extended at a minimum cost. In my experience hard, abrasive surfaces are not as satisfactory as the more elastic or resilient types. When taking off, resilience, without undue retarding of the wheels of the running year, is desirable. On landing, the same resilience relieves somewhat the impact shock on the landing gear. The tail-skid, of course, is one of the contact points, both in taking off and landing. On a hard surface it rapidly is worn off. It should, however, be gripped more by the elasticity than by the roughness of the surface. What appear to me, untutored as I am in road lore, to be the most satisfactory types are those in which asphalt is the cementing material and in which the asphalt forms both the elastic support and the non-skid surface.

### IMPORTANCE OF AIRPORT DIRECTION SIGNS.

That is my somewhat weak contribution to this meeting. I don't know a great deal about it, gentlemen. As I said before, I have never read a paper in a meeting before. I have always talked extemporaneously and it is a little awkward for me to do it this way. I thank you for this opportunity to discuss this subject of airport surfacing and I assume now that there will be some discussion. I notice that my good friend Major Doolittle has been taking notes and probably will be upbraiding me for some of my arguments. Anyway, for the benefit, once again, of the Memphis people, I want to say that Jimmy Doolittle also had a little trouble in finding the airport here because it was not marked. He, too, had to look around and he landed north of town. I say that again because, on a bad day, it is rather important that a city be marked to indicate the direction of its airports so as to guide aviators when, perhaps like myself, they have no map to guide them. I assume that this paper is now open for discussion.

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CHAIRMAN SKIDMORE: I am sure, Captain Hawks, we appreciated and we enjoyed hearing you express your opinion on this subject. The discussion will be opened by Major Doolittle.

## DISCUSSION.

MAJOR J. H. DOOLITTLE, St. Louis, Mo.: Gentlemen of the Asphalt Conference: After Frank's discourse I am a little at loss to know just how to pick it to pieces. In fact, I really want to cheer him on. I feel very ill at ease in getting up here and talking about asphalt before asphalt technologists and I can only excuse myself by saying that I do have some knowledge of what an aviator would like to have to land on. It brings to mind a story. An admiral came out and talked to a flying school where I was stationed a short time ago. There were about two hundred pilots sitting there listening to the address. We all looked at the admiral when he arose and we were amazed to find that he did not have wings. He prefaced his talk with a few remarks of explanation. He said, "Gentlemen, I like eggs. I know a good egg when I see one, but I have never laid an egg."

Frank brought up the point that runways should be as soft as it is possible to have them, without having any oil getting on the tires and damaging them and without having any retarding effect in taking off. The aircraft designer is very anxious to build his plane as light as possible. In order to build it that way he has to have each part as light as possible. The landing gear is a considerable part of the airplane and if the place where the aviator lands is built to absorb some of the shocks rather than transmit them to the airplane, the designer can build lighter airplanes. That is one of the advantages of asphalt as an airport covering material. It has some "give" to it.

There is a well known field in New York which has asphalt runways that are not quite properly built. The main trouble is that they are crowned too much. In building runways the absolute minimum of crown should be provided that will give proper drainage, because an airplane has a tendency to run down hill. On this particular airport a great many airplanes have been wrecked through a tendency to leave the runway.

At the present time in the interest of economy, runways are built narrower than they should be. I recall that in 1923 when they first started to put down runways in Boston the runways were one hundred and fifty feet wide. I was in Boston last week and I found that they had lately built in about half of the space between the runways. We look forward in the future not to a runway field, but to a field that is covered entirely with some material that will keep it free of mud and that will permit the pilot to land and take off on any part of it. We feel sure, from the point of view of experience, economy and general utility, that the material will be asphalt.

CHAIRMAN SKIDMORE: I am sure that we are all more than glad to hear from these men who know so much about the air angle of it so that we can conceive some better way of building runways or airport surfaces to suit their requirements. Col. Jouett is scheduled to speak in the regular course of the program. However, we would like to hear from him now if he has anything to say on this particular subject.

COL. JOHN H. JOUETT: I don't know, Mr. Chairman, whether I should take up the few points I have in mind now or following the reading of the committee's report.

CHAIRMAN SKIDMORE: Well, I think you might take them up now.

COL. JOUETT: Well, then, gentlemen of the conference, from Capt. Hawks and Major Doolittle I think you probably have heard as much as can be said on the runway and taxi situation at airports. There are certain things that come to my mind, however, on the question of the flooring of the hangars, which point has not been brought up and yet it is a very necessary point for discussion, I believe. The flooring used today in the hangars in many instances is the original dirt floor without any surfacing. There is no need to point out the many disadvantages of the dirt floor in the way of unevenness and everything else. Concrete is quite generally used but the use of asphalt is becoming more and more popular in the hangars as a flooring material.

There are also two or three other points that I wanted to bring out.

One of them—the main one in my opinion—is the question of the fire hazard, which too many times has been overlooked in the construction of airplane hangars. I know at Langley Field some years ago, about 1919 or 1920, when I happened to be in command of the lighter than air activities there, we were constructing the first large hangar in that part of the country. At least it was the first that the U. S. Army constructed. As you know, in those days we used hydrogen gas instead of helium. Hydrogen has a very highly explosive characteristic, as you know, and is a great fire hazard. Many very serious and fatal accidents have occurred by reason of the explosion or combustion of hydrogen. The question of flooring came up and the government decided that the matter of expense did not enter into it since the cost of human life cannot be measured in money. It was decided that concrete could not be used for the reason that the steel tools necessary for some of the mechanical work, when dropped upon concrete, are liable to cause a spark. People going through the hangars with steel plates on their heels, or with nails protruding from their heels, may cause sparks and that is equally dangerous. So, after a great deal of very careful investigation, the officials decided upon a plastic floor and it was laid. As you can realize, it was put in at much greater cost then concrete and some other materials. That practice has been followed in all the hangars where the necessity for keeping down the fire risk is great.

I wrote to the United States Aviation Underwriters of New York City on this question, asking them if the insurance people recognized a difference in the fire risks incident to the flooring of the hangar and I received a reply from Reed Chambers, who is vice-president of the concern. In his reply he says:

> About two years ago, Al Johnson's hangar at Dayton, Ohio, burned during the night and the story of the watchman was to the effect that he was walking across the cement floor when it burst into flames presumably caused by sparks from the nails in his shoes, plus a leaking gas tank.
>
> At one of the National Board of Fire Underwriters' meetings, I brought up this point and asked if anyone had worked out a non-sparking floor composition that was satisfactory from every viewpoint. I was told that so far as any one knew, this had not been done and that in workshops where high explosive mixtures were used, wooden floors usually were used and, if concrete were necessary for other reasons, rubber shoes were required to be worn by workmen. In fact, a considerable controversy arose as to whether or not the sparking from hobnailed shoes would ignite gasoline on the floor and the matter was promptly forgotten.

Those are matters that cannot be forgotten. I have noticed that in concrete floorings, if there is a leaking gas tank, the gasoline itself sometimes will form a pool in any slight depression that may exist in the floor. The only way it has to dissipate itself is through the air. On an asphalt floor it rapidly soaks into the flooring and becomes a part of the asphalt. That does not in any way increase the fire hazard. For that reason alone I think a great deal of consideration should be given to asphalt for hangar floors. There are also other minor considerations like concrete being harder on your feet and colder in the winter, as against the warmer and more resilient qualities of asphalt.

That brings to my mind a point that has been brought up quite a few times; that is, that leaking gasoline on the asphalt will cause a soft spot which, through scuffling around, will develop into a hole and, therefore, cause unevenness in the floor. I think that point is rather highly overrated. At Fort Crockett, where the attack group is stationed, there is one hangar that has asphalt flooring which has been down about three years. The attack ships are kept in that hangar all the time. From thirty to thirty-five of them are sandwiched into it. These ships weigh from one to two tons each, depending on how much gasoline they carry. The tail-skids and the other points take up this entire weight. That floor is as good today as it was on the day it was put in and, despite the thought that we would have to keep a pot on hand with which to fix it, it has not been found necessary to do that. I bring this out to prove what actual experience has shown, rather than as a theoretical proposition on that point.

A very peculiar case happened yesterday. I was taking off from an airport and a very good flyer in Tallulah was present. I happened to mention that my motor seemed a little rough. He said "What kind of runway have you down there at New Orleans?" I said: "The runway is of packed shell with a lot of loose shell around the taxiways." He said he had a peculiar experience the other day. "I heard a fairly large stone being picked up by my propeller," he declared. "I distinctly heard the click which all of us have heard while warming up planes where loose stones are present and the impact of that stone against my propeller threw it out of line enough to cause vibration in the motor." That corroborates the point that Capt. Hawks brought out on the question of stones being thrown into the ship. It is something that we have to watch. You have to bind well the materials that you are going to use for surfacing around an airport.

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CHAIRMAN SKIDMORE: Gentlemen, I am sure we are all very appreciative of what these men have had to say. While we are on the subject of airport construction, we will proceed with the report of the Committee on Airport Surfacing, to be presented by the chairman, Mr. William N. Carey, chief engineer of the Department of Public Works at St. Paul, Minn.

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# Survey Report of the Committee on Airport Surfacing Methods

### By William N. Carey, St. Paul, Minn.

*Chairman*

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Early this year the division of commercial research of the Curtis Publishing Co., issued a splendid report on "The Aviation Industry." This report by far is the most comprehensive and authoritative statement on the aviation industry yet published. One of the outstanding conclusions given in the report is as follows: "The importance of more and better airports cannot be stressed too strongly for upon the creation and maintenance of numerous and well equipped airports the aviation industry must depend for its future development." (p. 104) Note that the Curtis research group expresses no serious concern over the development of airplanes or airways or of probable passengers and freight for air carriers but does place the future success of the aviation industry upon the development of airports, which are the terminals of the air lanes.

### Relation of Aviation to the Asphalt Industry.

It may not be clear to all why success of the aviation industry is important to persons primarily interested in the asphalt paving industry and allied construction. The aeronautics branch of the U. S. Department of Commerce reports as of November 1, 1930, the existence in the United States of 1,813 airports and landing fields of all kinds. There were also, on the same date, 809 new airports proposed for early construction. Together, these figures give us 2,622 airports and landing fields now in use or in immediate prospect. Aviation prophets assert that there will be at least ten thousand airports in use in the United States alone when aviation gets into its stride. In any consideration of figures on airports, existing and proposed, the distinction between an airport and a landing field should be kept in mind. This difference is much the same as that which exists between a railroad terminal, with its passenger station, freight houses and other terminal facilities, and a flag-station stop with perhaps nothing more than a side-track and a wooden sign-post. There are as many degrees of railroad stations between these two limits as

T. A. T. Airport, Waynoka, Okla., During Construction. Note Oil Treated Taxiway and Runways.

there are between the terminal facilities of the Cicero Municipal Airport at Chicago and the smooth, green pasture used as a landing field at Hudson, Wisconsin. The flag-stop railroad station of today is the small town of tomorrow and may be the large city of the future. Similar potentialities exist with regard to any unimproved landing field which today is used but little, but which may be the highly improved air terminal of tomorrow, or at least an important station on some heavily traveled air lane.

### NEED OF SUFFICIENT NUMBER OF AIRPORTS

At present there are but 619 of the 1813 airports and landing fields which have *any* night lighting equipment. At best there probably are not more than 500 air fields in the United States today which have sufficient facilities and improvements to warrant classification as airports. Of the 2,600 existing and proposed airports and landing fields, like eggs being hatched, only about 500 have actually been hatched out and the remaining 2,100 are in the process of hatching. A glance at recent aviation statistics will prove that they are hatching. More passengers traveled by air during the first six months of 1930 than during all of 1929. The same six months saw a very substantial increase in tonnage of air mail and express. What other nation-wide industry has doubled any large part of its business during the past year? American air transports, operating on regular schedules during the first six months of 1930, flew 16,903,000 miles, compared with 9,200,000 for the first six months of last year.

More ships in the air require more terminals on the ground. As stated, we have now about 1,800 air terminals and fields of all kinds in use and about 800 more are proposed or under construction. To be conservative let us assume that there are 2,000 airports which now need, or will soon need, at least some kind of surface treatment to keep down dust and which, as the industry develops, will require hard surfaced, dustless runways, aprons and taxi-ways. A conservative estimate of the minimum area required to be surfaced for runways, aprons and taxi-ways for a single well developed airport is 150,000 square yards. The total requirement for 2,000 airports at that rate would be three hundred million square yards. To surface these runways with even a bituminous, mixed-in-place surface at fifty cents a square yard would cost one hundred and fifty million dollars. These are but guesses, it is true, but the figures are by no means outside the realm of probability. They are close enough at least to indicate that a successful aviation industry will open to the asphalt construction industry a vast market so far almost untouched.

### IMPORTANCE OF DRAINAGE AND SURFACING

Recognizing the importance of airport surface development to the asphalt construction industry, the chairman of the present asphalt paving conference recommended that a committee of engineers be formed to make a survey of present practice in airport surfacing and to make a report on the subject to this conference. The following committee was appointed: P. J. Freeman, chief engineer, Bureau of Tests and Specifications, Allegheny County Department of Public Works, Pittsburgh; Mark R. Thompson, engineer in charge of bituminous pavements, Board of Public Service, City of St. Louis; Col. R. Keith Compton, director of public works, City of Richmond, Va., and W. N. Carey, chief engineer, Department of Public Works, St. Paul, Minn., chairman.

A general review of airport development to date brings to light no new major problems. Engineering practice covering airport surfacing appears to be just beginning to take definite form. The two major problems which are to be solved first in the successful construction of any airport are drainage and surfacing, the "Siamese Twins" of trouble to whom none of us connected with airport construction needs an introduction. While we recognize the inseparability of the twin problem, we have confined our survey and this report to an attempt to get better acquainted with but one of these twins, airport surfacing.

T. A. T. Airport at Kingman, Ariz. At this Airport the Runways are Surface Treated with Oil.

Practically all of the airport surfacing and paving in place today has been placed during the past two years. The scarcity of surfaced or paved airports to date prevents the drawing of any very definite conclusions. Trends, only, can be observed. When we consider the evolution of street and highway paving practice through the past twenty-five years, our short airport surfacing experience of two years will not loom large. However, a survey of progress and practice for even a two-year period should be valuable.

### Nature of Questionnaire Sent Out

A questionnaire was drawn up and mailed to approximately 800 persons. Replies were returned from 153 airports, including nearly every important airport in the United States, one from Alaska and another from the Panama Canal Zone. A list of the airports from which questionnaires were returned and tabulations of the returns are contained in the appendix to this report. The questionnaire contained twenty one short questions as follows:

(1) What is the name of your airport?
(2) Is it privately or publicly owned?
(3) Are any of your runways, landing strips, warming-up aprons, hangar aprons or service roads paved or surface treated?
(4) If so, by what method and what materials?
  (a) Runways?
  (b) Landing strips?
  (c) Warming-up aprons?
  (d) Hangar aprons?
  (e) Service roads?
(5) Give cost data covering paved or surface treated areas.
(6) What method or treatment have you found most suitable, considering service requirements and costs?
(7) What, if any, were the principal difficulties encountered in paving or treating the various areas of your airport?
(8) How do you maintain or plan to maintain paved or treated areas?
(9) What is your estimate per square yard of the annual maintenance cost?
(10) What would you recommend as a minimum width for (a) For paved or surface treated runway? (b) For taxiway?
(11) Do you believe that there is some form of bituminous surface treatment (not paving) which will prove generally satisfactory for runway use?
(12) Under what general conditions, if any, do you believe some form of bituminous surface treatment would be unsatisfactory for runways?
(13) What types of surface do you consider suitable for treatment with bituminous materials in runway construction?
(14) Assuming a well drained subgrade on a major airport and construction costs approximately equal, what type of runway pavement do you prefer, rigid or non-rigid?
(15) Do you believe that turf of sufficient toughness can be grown and maintained economically for landing strips?
(16) For airports having or anticipating heavy traffic requiring high types of runways and justifying heavy expenditures, what do you consider the most desirable type of pavement?
(17) In what respect do you consider it the most desirable?
(18) What type of hard surface do you consider unsuitable for runway construction and why?
(19) Should a runway in your opinion be crowned so as to drain water toward the shoulders or should it be dished slightly to drain water away from the shoulders and toward the center?
(20) What types of surfacing or pavement do you consider best

adapted to use for the purposes listed below?
(Name in order of preference.)
(a) For hangar floors used for service hangars?
(b) For hangar floors used for dead storage?
(c) For aprons?
(d) For taxiways?

(21) (a) For night use on an airport well flood-lighted, is there any preference from a standpoint of visibility between landing on a light colored runway pavement or on a black pavement having wide white borders?
(b) Which, if either, do you prefer?

The questionnaire was fairly satisfactory in obtaining usable answers, though the returns indicated a lack of clearness in some of the questions. We could make a better questionnaire on the same subject now. We should have defined clearly what we meant by the terms "surface treatment," "pavement," "rigid" and "non-rigid pavement" as there appears to be little uniformity of thought as to exactly what these particular terms mean.

### OBSCURITY OF MEANING IN QUESTIONS ASKED.

There were other items upon which the questionnaire failed to mean the same thing to all recipients. On the whole, however, it proved sufficiently satisfactory and was answered by a surprisingly large number of airport managers and engineers. The committee desires to express its thanks to each of these men for his kindness and courtesy in helping us to make a representative survey of present airport surfacing practice. General information on the number of questionnaires returned, as well as ownerships and ports with some pavement or surface treatment is given in Table 1.

TABLE NO. 1

*General Information*

| | |
|---|---|
| Airports and landing fields now operating (Nov. 1, 1930) | 1,813 |
| Proposed new fields (Nov. 1, 1930) | 809 |
| Questionnaires mailed | 800 |
| Questionnaires returned undelivered | 30 |
| Questionnaires probably received | 770 |
| Replies returned | 153 |
| Percentage of returns | 19.88 |

THOSE REPLYING.

*Airports*

| | |
|---|---|
| Publicly owned (municipalities) | 57 |
| Publicly owned (U. S. Government) | 18 |
| Privately owned | 52 |
| Ownership not stated | 26 |
| Ports with no surface treatment or pavement | 92 |
| Ports with some surface treatment or pavement | 60 |
| Ports with runways, whole or in part surface, treated or paved | 32 |
| Ports with runways, whole or in part surface treated or or paved | 121 |

The most surprising fact developed by our survey is that of the 153 airports reporting, only 32 have all or part of their runways surface treated or paved. The remaining 121 get along with natural soil or turf for runway purposes.

### ELIMINATING DUST AT THE AIRPORTS

There are two major discomforts connected with air travel, noise of the plane and wind and dust at the airport. This generally is recognized wherever interest in aviation exists. The dust discomfort can be overcome easily and cheaply by surface treatment but our survey showed that there are comparatively few airports where anything is being done to eliminate this serious handicap to air travel. The Curtis Publishing Company's report mentioned earlier, states (p. 58): "In most airports dust raised by the air stream from passing planes and from motors being warmed, or blown by a wind sweeping the field, is a major discomfort which must be abated if air travel is to become popular. Hard surface aprons and runways and oiling of fields, are some of the things which can help."

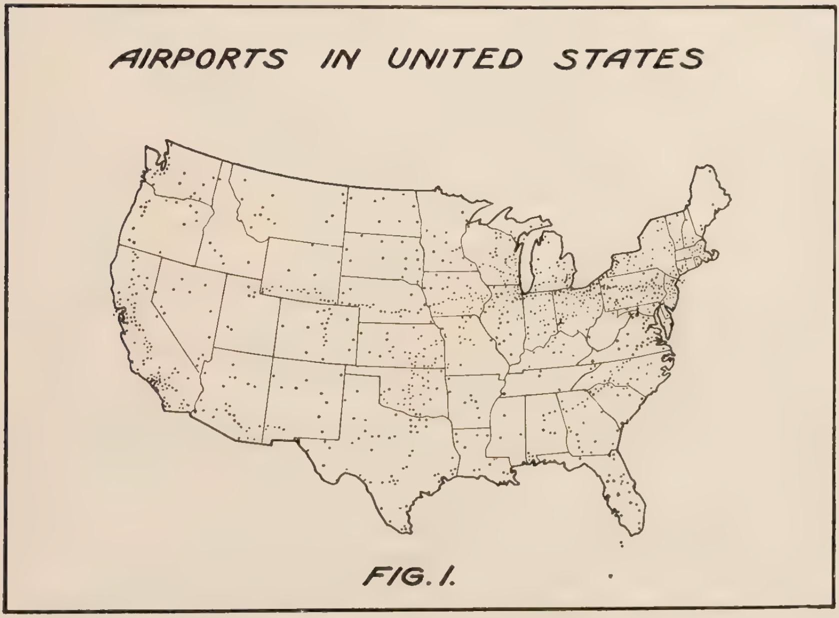


FIG. 1.

Two outline maps of the United States are submitted; one designated as Fig. 1, showing the location of most of our airports as reported by the Department of Commerce early this year and the other, Fig. 2, showing the location of airports from which replies to our questionnaire were received. In the reply map, airports with some surface treatment or pavement are shown by solid circles and those without surface treatment

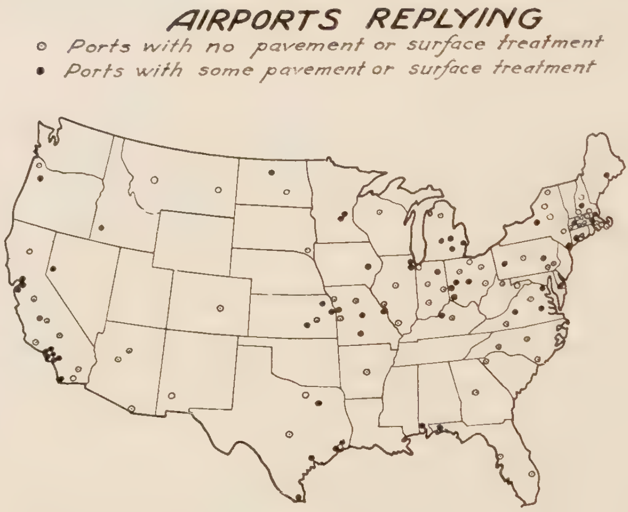

AIRPORTS REPLYING
○ Ports with no pavement or surface treatment
● Ports with some pavement or surface treatment

FIG. 2.

or pavement are shown by open circles. The reply map, Fig. 2, shows graphically the wide distribution of the replies received.

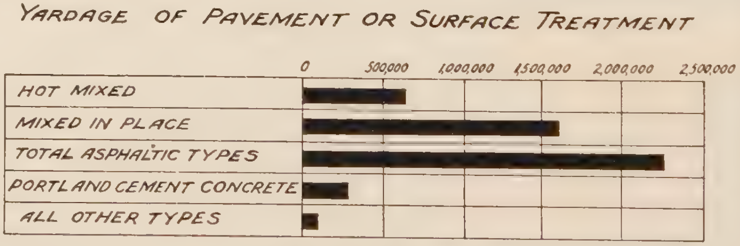
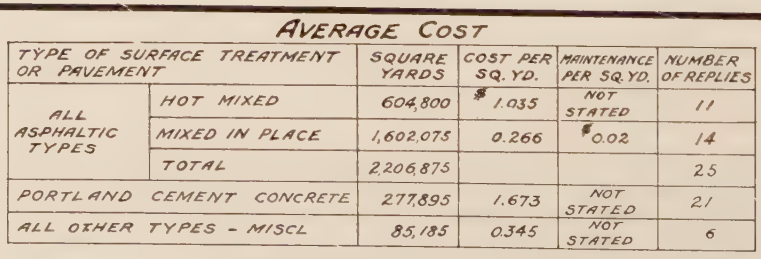


Table 2.



AVERAGE COST

| TYPE OF SURFACE TREATMENT OR PAVEMENT | | SQUARE YARDS | COST PER SQ. YD. | MAINTENANCE PER SQ. YD. | NUMBER OF REPLIES |
|---|---|---|---|---|---|
| ALL ASPHALTIC TYPES | HOT MIXED | 604,800 | $1.035 | NOT STATED | 11 |
| | MIXED IN PLACE | 1,602,075 | 0.266 | $0.02 | 14 |
| | TOTAL | 2,206,875 | | | 25 |
| PORTLAND CEMENT CONCRETE | | 277,895 | 1.673 | NOT STATED | 21 |
| ALL OTHER TYPES - MISCL | | 85,185 | 0.345 | NOT STATED | 6 |

TOTAL NUMBER OF REPLIES ON ALL TYPES ........ 52

Table 3.

### WIDE DIVERGENCE IN THE COSTS REPORTED

Yardages and types of surface treatment are shown in Table 2. Costs always are difficult to obtain. Table 3 shows the average costs of various types as closely as they could be determined from the returns. The wide divergence reported in the cost of runway treatment—from 22 cents a square yard for thin bituminous surface treatment to $1.75 for two-inch hot mix asphaltic concrete on three-inch "black base"—indicates not only a wide divergence in soil conditions and air traffic conditions but a wide difference of opinion among engineers as to the expense justified for runway surfacing. Table 4 shows a summary of the purpose for which the various types of surfacing and pavements are used. It is interesting to note that, while there were but two Portland cement concrete runways reported, nearly all of the aprons were shown to be of Portland cement concrete.

TABLE 4.

*Types and Uses.*

| Types | Uses | | | | |
|---|---|---|---|---|---|
| | Runways | Landing Strips | Aprons | Taxi-ways | Service Roads |
| Portland cement concrete pavement | 2 | 2 | 39 | 1 | 8 |
| Bituminous pavement | 11 | 9 | 12 | 3 | 10 |
| Bituminous surface treatment | 14 | 7 | 8 | 0 | 9 |
| Other types — treatment or pavement | 2 | 0 | 4 | 0 | 11 |
| Total replies | 29 | 18 | 63 | 4 | 38 |

Question six, "What method or treatment have you found most suitable, considering service requirements and costs?" brought out some interesting replies which are summarized in Table 5.

TABLE 5.

*Most Suitable Surface Treatment.*

| | |
|---|---|
| Answers received | 41 |
| Turf | 9 |
| Portland cement concrete | 6 |
| Tarvia macadam | 2 |
| Bituminous, mixed-in-place or penetration | 15 |
| Asphalt pavement | 7 |
| Miscellaneous | 2 |

Some of the smaller cities, such as Keene, N. H., Clearwater, Fla., Martinsville, Va. and Bedford, Ind. have found that turf is best for their requirements. Others of the smaller cities, such as Fresno, Cal., Selma, Cal. and Bridgeport, Conn., prefer oil treatment to turf even for light traffic, while Helena, Mont. has found calcium chloride treatment to be satisfactory.

### LITTLE DIFFICULTY IN SURFACE TREATING.

The persons answering question seven did not indicate that any one of them had met with any great difficulty in connection with any paving or surface treating they may have done. Of thirty replies to the question, "What, if any, were the principal difficulties encountered in paving or treating the various areas of your airport?" fourteen replies were, "None." Seven experienced trouble with drainage, three had a hard time finding the type of road oil which best would meet their surfacing requirements and four found trouble in paving directly on top of loose, hydraulic sand-fill. The remaining three ports admitted varied difficulties. My personal sympathies lie with Bridgeport, Conn., the San Francisco Bay Airdrome and Atlantic City, N. J., in placing their pavements on loose hydraulic sand-fills. At St. Paul, two runways, a road and an apron were paved directly upon hydraulic fill and the job is one to be avoided, if possible, though the results are excellent.

### Ideas as to Width of Runways.

We hoped to obtain some new ideas from questions eight and nine, requesting plans for maintaining paved or surfaced areas and the estimated costs of maintenance. Twenty-eight airports admitted having plans for maintenance of the paved areas and the estimates as to the maintenance costs ran from 30 cents a square yard down to one-half cent a square yard. The average of most of the estimates is about two cents, which appears high. The methods proposed were the usual ones for maintaining bituminous treated surfaces and asphalt pavements. From the Fairfax Airport at Kansas City, where asphalt macadam runways were reported, came the reply that no maintenance would be required and from the Blanchfield Municipal Airport at Reno, Nev. came the reply that no repairs have been found necessary on a "hot-rolled bitulithic concrete" hangar apron at the airport since 1920.

The question as to what is the proper minimum width for a paved or surface treated runway has been considered by every airport designer. Ideas on this subject from 64 airports are shown in Table 6. The majority vote, 27, goes for a minimum width of 100 feet. Results on the same question covering taxiways also are shown in Table 6. Of 61 replies, the majority favor taxiways of not less than 50 feet but there is less uniformity of opinion on taxiways than exists on runway widths.

Table 6.

*As to Minimum Width of Runways*

Answers received .............. 64

| Widths recommended ...... | 25 | 50 | 75 | 100 | 120 | 150 | 200 | 250 | 300 | 400 |
|---|---|---|---|---|---|---|---|---|---|---|
| No. of answers .... | 2 | 3 | 1 | 27 | 1 | 9 | 16 | 2 | 2 | (a)<br>1 |

(a) Recommended for military formations only.

*As to Minimum Width of Taxiways*

Answers received .............. 61

| Widths recommended .... | 10 | 20 | 25 | 30 | 40 | 50 | 60 | 70 | 75 | 100 | 200 | 400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of answers ... | 1 | 1 | 3 | 2 | 6 | 17 | 3 | 1 | 4 | 20 | 2 | (a)<br>1 |

(a) Recommended for military formations only.

Opinion was very much desired on the question as to whether or not some form of bituminous surface treatment, not pavement, would prove satisfactory generally for runway use. Question eleven put this query and Table 7 indicates the replies received from 49 fields. The answer from Lambert Field, St. Louis, which probably has the most complete information to date on this subject, summarizes all of the replies. Lambert Field says, "Yes. 'Mixed-in-place' will work on 85 per cent of all air fields."

TABLE 7.

*Is some Form of Bituminous Surface Satisfactory?*

| | |
|---|---|
| Replies received | 49 |
| No | 6 |
| Yes | 41 |
| Answer qualified and not definite | 2 |

Question twelve was intended to be a corollary to eleven. The question was: "Under what general conditions, if any, do you believe some form of bituminous surface treatment would be unsatisfactory for runways?" From the replies received we are forced to conclude that the question was not worded properly. It was not clearly understood and all sorts of answers were received. Most of those who understood and answered, expressed the opinion that there were soil and drainage conditions in some localities which would make the use of bituminous surface treatment for runways unsatisfactory. Three fields expressed some concern relative to probable damage by tail-skids and one objected to the black color.

### BITUMINOUS SURFACING FAVORED AT FRESNO.

From the Fresno, Cal., municipal field came the opinion that there are but few conditions where bituminous surface treated runways would prove unsatisfactory. St. Louis goes further and states in effect that there are no soil or drainage conditions which cannot be rectified sufficiently to permit construction of successful bituminous surface treated runways. Lambert Field, St. Louis, reports 80,000 square yards of bituminous surface treatment by oiling and 128,000 square yards of cold-mixed asphaltic concrete runways and taxiways, four inches thick, all laid after exhaustive experimentation both in the laboratory and on the field.

Question thirteen was an attempt to obtain additional opinion on the subject of surface treatment. This question was intended to bring out the types of soils thought most suitable for bituminous surface treatment. There was some misunderstanding on this question also, but the replies from most of those who understood the question were to the effect that a sandy and well drained soil lent itself most readily to bituminous surface treatment.

Question fourteen has been discussed at length by pilots and engineers for several years. Is a rigid or a non-rigid runway surface preferable at a major airport? Table 8 shows the preferences expressed.

TABLE 8.

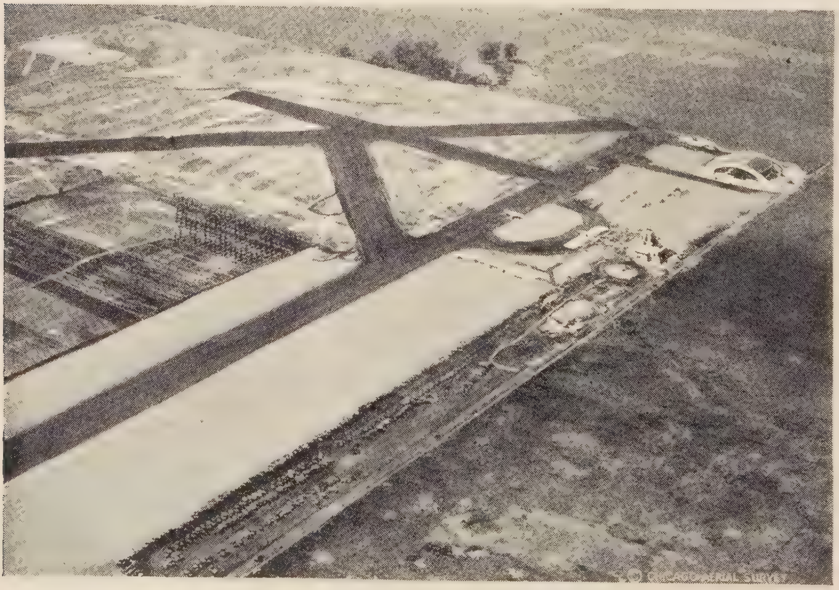
*Preference for Rigid or Non-Rigid Runway Pavement*

| | |
|---|---|
| Answers received | 55 |
| Favoring a rigid type | 12 |
| Favoring a non-rigid type | 39 |
| No preference | 1 |
| Favoring a rigid type for take-off and non-rigid type for landing | 3 |

Preference strongly is for the non-rigid runway, though some expressed preference for a rigid pavement for take-offs and a non-rigid surface for landing. It should be borne in mind in connection with the answers to this question that while Portland cement concrete unquestionably is a rigid pavement, there are bituminous types, which, from the viewpoint of a pilot making a landing, are also rigid. A runway built of three or four inches of "black base," hot mixed and topped with an inch and a half or two inches of hot-mixed asphaltic concrete, or a runway of the penetration type, if of sufficient depth, is, from the pilot's viewpoint, just as rigid as Portland cement concrete.

### TEXTURE MORE IMPORTANT THAN RIGIDITY.

We do not believe that there is any practical difference in the mechanical reactions taken up within a landing ship when landing upon either a rigid or a non-rigid runway, provided that the runway presents to the



SKY HARBOR AIRPORT NEAR CHICAGO, ILL. AT THIS AIRPORT THE RUNWAYS CONSIST OF TWELVE INCHES OF CINDERS TREATED WITH OIL.

landing ship a material which is of sufficient stability to withstand the impact without excessive and permanent displacement or cutting. This belief can be supported mathematically. Granting a stable runway, the texture of the runway surface appears to be of much more importance than the exact degree of rigidity present in the runway structure. The kind of a surface on the runway, whether it be smooth like sheet asphalt, or gritty and granular like a seal coat of asphalt and stone chips, is of tremendous importance to the pilot. For the smaller ships and some of the big ones, too, carrying tail-skids, surface texture means at least as much as the material which lies below the surface. Our question as to preference for rigid or non-rigid runways would have been of more value had we developed with it the question of surface detail.

Answers to question fifteen, on the suitability of turf for landing strips were divided and qualified, as shown in Table 9.

TABLE 9.

*Turf for Landing Strips.*

| | |
|---|---|
| Answers received | 87 |
| Yes, unqualified | 15 |
| Yes, for light traffic | 33 |
| Yes, if tail-skids are excluded | 13 |
| No, unqualified | 26 |

The replies indicate that all who answered the question did not notice that it covered sod for landing strips and not for runways. A landing strip, as defined by the Department of Commerce, is a strip at least 500 feet wide. The majority of opinion appears to be against turf except for light traffic.

## OPINION AS TO ASPHALT AND CONCRETE.

Question sixteen was: "For airports having or anticipating heavy traffic requiring high types of runways and justifying heavy expenditures, what do you consider the most desirable type of pavement?" Then question seventeen, "In what respect do you consider it the most desirable?", brought out some interesting reasons for the opinions given in answers to question sixteen. The proponents for Portland cement concrete for high-type, heavy-duty runways offered as reasons for their preference, durability, smoothness, visibility, low maintenance costs, resistance to frost action, non-skid, appearance and low first cost. The proponents of bituminous paved runways believe their type most desirable because of low first cost, durability, low maintenance costs by simple methods, dustless, non-skid, resilient, no glare at night or during the day, visibility with white borders, less wear on tires, appearance, ease of extension and smoothness. For airports, other than those receiving heavy traffic, the general opinion expressed is that some form of bituminous, "mixed-in-place" surface treatment would be satisfactory for runways in 85 per cent of all such airports. When real heavy duty is required of a runway and funds are available for expensive construction, the score from 67 airports appears to be a draw as between bituminous and Portland cement pavements for the runways.

TABLE 10.

*Heavy Duty Runway Pavement Preferred.*

| | |
|---|---|
| Answers received | 67 |
| For bituminous types | 24 |
| For bituminous pavement for landings and Portland cement concrete for take-offs | 7 |
| For either bituminous types or Portland cement concrete | 8 |
| For Portland cement concrete | 24 |
| Miscellaneous | 4 |

As questions sixteen and seventeen obtained opinions on the kinds of a pavement which should be used, question eighteen was intended to determine what types of hard surface *not* to use. Some of the answers will bear recording. Seven replies to question eighteen, out of thirty-three received, were to the effect that Portland cement concrete for runways is too hard, too rigid and too smooth for safety. Four are against brick because of the roughness and rigidity of surface. Seven pointed out the undesirability of untreated crushed rock or cinders because of dust and damage to propellers. Five replies were against either bituminous treatment or pavement because of roughness, rolling or shoving.

## PROBLEM OF THE SHOULDERS FOR RIGID RUNWAYS.

While these five statements unquestionably were expressions of honest opinion, it should be borne in mind that roughness, rolling or shoving are not defects inherent in the bituminous types and can only result from improper choice of materials or from other faults in design or construction. One other reply expressed disfavor of any and all hard surfaced runways because "the shoulders require constant maintenance." Yet this same airport reports 100,000 square yards of bituminous treated runway and apron surface and prefers a non-rigid type of surface for the runways of a major airport.

The answers to question nineteen are shown in Table 11.

TABLE 11.

*As to Form of Runway Surface Preferred.*

| | |
|---|---|
| Answers received | 68 |
| Flat | 2 |
| Flat, but sloped to drain | 2 |
| Dished | 23 |
| Crowned | 41 |

Should a runway be crowned slightly or dished? The big majority are in favor of the crown and three have no preference.

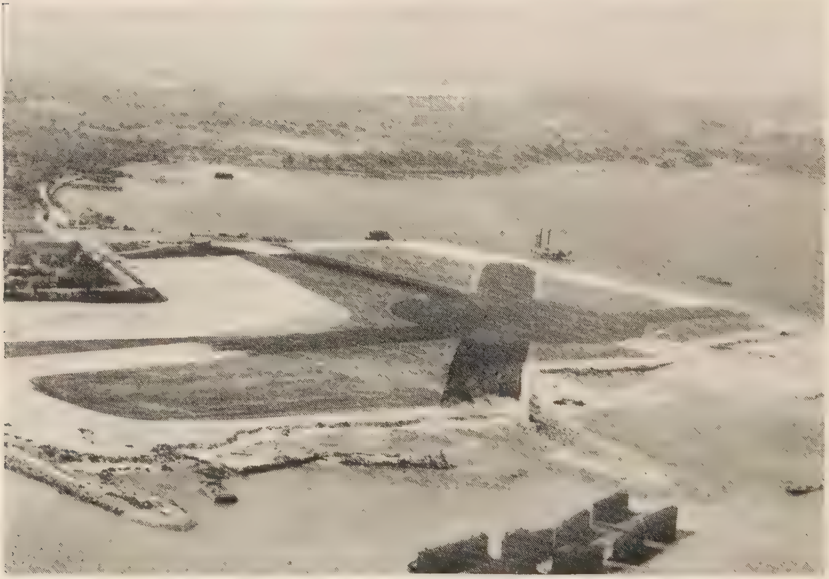
Forty-five replies were received to question twenty-one, as to whether or not there is any preference from a standpoint of visibility between landing on a light colored pavement or on a black runway with wide white borders. Four out of forty-five expressed no preference. Thirty preferred the light colored pavement because of visibility and eleven preferred the black pavement with white borders for the same reason. With night flying steadily on the increase, night conditions of runway surfaces become of more importance.

## NATURE OF CONSTRUCTION AT VARIOUS AIRPORTS.

Photographs of several airports were obtained and are submitted as visual evidence of present day airport surfacing practice. The airport at Waynoka, Oklahoma, has oil treated runways. This airport, as well as the T. A. T. Airport at Kingman, Ariz., are good examples of minimum oil treatment for runway surfacing. In each case the prairie bunch grass was bladed-off over the runway areas, followed by one or two applications of road oil and blading. This type of runway construction is used successfully at a great many of the T. A. T. airports in the western and southwestern arid territory.

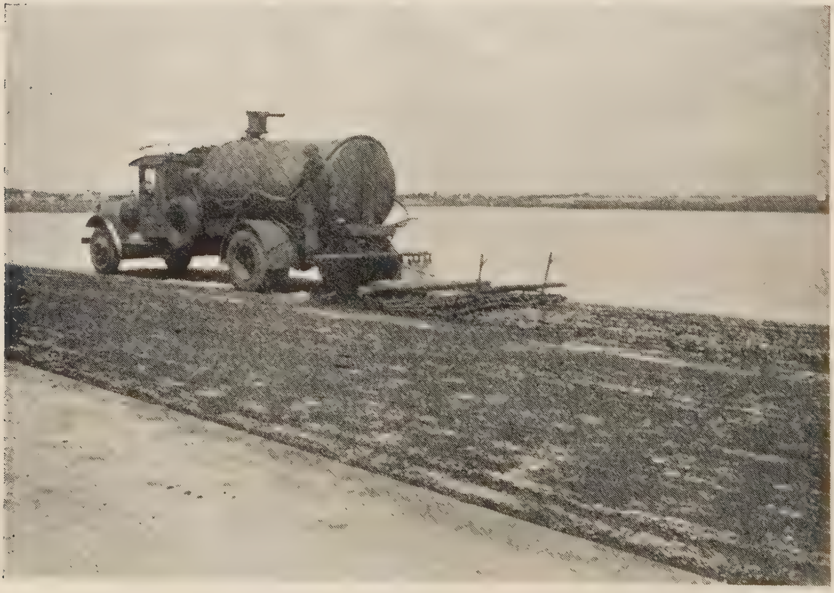
The Fresno, Calif., Municipal Airport, is an example of an oil treated area with the treatment somewhat deeper than the oil surfacing on the Kingman or Waynoka airport. The soil at the Fresno airport is a sandy loam. After grading, one and one-half gallons of road oil, with approximately 65 per cent asphaltic content, were applied hot in two applications. Each application was followed by harrowing and blading. The surface was not rolled, the blading having provided the desired smoothness. The bituminous surface treatment obtained is reported to be about two and one-half inches thick and the first cost was 4.8 cents per square yard. The oil was applied at 150 to 175 degrees F. During this last year of service which the Fresno airport has seen, it has been necessary to blade the runway surface for maintenance. In maintenance blading at Fresno, the blade is tipped slightly forward which partially compacts the surface, as well as smooths it.

UNITED AIRPORT, BURBANK, CALIF. THE RUNWAYS AT THIS AIRPORT ARE BITUMINOUS TREATED, ARE FIVE INCHES THICK AND ARE LAID IN TWO COURSES.



Glen Curtiss Airport, Near New York. The Aprons and Runways are of Penetration Macadam. Emulsified Asphalt was Used. The Circular Area is of Oiled Sand and Gravel.

The runways of Fairfax Airport at Kansas City, Mo., have a deeper



Construction of Runways at Roosevelt Field, New York. Pit Run Gravel was Used for the Base, Being Given a Treatment of One Gallon of Emulsified Asphalt to the Square Yard. The Penetration Course Consisted of Two Inches of Stone Aggregate.

"mixed-in-place" surfacing than the ports previously shown. The natural earth found at the site was mixed in place with successive applications, totaling three gallons of road oil and one and one-half gallons of cutback per square yard. A bituminous surfacing six inches in depth has been obtained. Each application of bituminous material was followed by the use of a disc harrow and a sheep's-foot roller. The final surface was smoothed by means of a five-ton roller.

### SLAG AND CINDERS USED AT CHICAGO.

The Cicero Airport at Chicago is one of the half dozen terminals in the country carrying very heavy traffic. The runways at the Cicero field are built up with twelve inches of slag and cinders and are surface treated with road oil. These runways are proving fairly satisfactory, but a heavier type of runway is indicated as being more desirable for this traffic. The Sky-Harbor Airport near Chicago, has runways with twelve inches of cinder surfacing treated with road oil. The appearance of the main building, compared with buildings at most of the other airports in this country, is particularly imposing. The Municipal Airport at Kansas City, Mo., is another example of the cinder runway treated with road oil. The runways here still are subject to some ravelling but it is intended to improve them with additional applications of road oil.

One of the best known airports on the western coast is the United Airport at Burbank, near Los Angeles, Cal. This airport is 237 acres in extent. The natural soil used is a sandy loam. The bituminous treated areas were built up in two lifts, each two and one-half inches in thickness, by means of blading and harrowing. The base course took one

VIEW OF THE ASPHALT TREATED LANDING AREA AT ROOSEVELT FIELD ON LONG ISLAND, NEAR NEW YORK.

gallon of hot road oil per square yard, and the top course another gallon of road oil, per square yard. The top was rolled thoroughly after blading. The resultant five-inch thickness of bituminous treated runways gives a very resilient surface, which takes the marks of wheels but which irons out again under traffic without excessive displacement. It is believed at Burbank that, as traffic on the airport increases, it will be necessary to work crushed stone into the runway surface in order to increase the stability. The turn-around pads, taxiways and service roads at the Burbank airport are of hot-mixed, coarse aggregate asphaltic concrete.

### TREATMENT OF SOIL AT SANTA MONICA AIRPORT.

A general view of the single landing strip at Clover Field, Santa Monica, Cal., is very imposing. The natural soil of the landing strip was given a thin oil treatment, at a costing of 11 cents per square yard, for 192,000 square yards. An additional 22,000 square yards of landing strip were given a somewhat heavier treatment of emulsified asphalt at a cost of 22 cents per square yard. Warming up aprons and parking space amounting to 26,000 square yards were surface treated with road oil and emulsified asphalt. Clover Field has, in all, 240,000 square yards of bituminous surface treatment, which constitutes one of the largest single areas in the United States that is so treated.

AIR VIEW OF ROOSEVELT FIELD, NEW YORK. THE RUNWAYS, BUILT IN 1930, CONSIST OF A FOUR-INCH GRAVEL BASE BOUND WITH ONE GALLON OF EMULSIFIED ASPHALT TO THE SQUARE YARD AND A TWO-INCH LIMESTONE PENETRATION MACADAM WEARING SURFACE BOUND WITH TWO GALLONS OF EMULSIFIED ASPHALT TO THE SQUARE YARD. COST, ONE DOLLAR PER SQUARE YARD.

An airport which probably is destined to become one of the most active air terminals in the country is the Glenn Curtiss Airport on Long Island, N. Y., which accommodates both land and water planes. The field proper is made up of sand, gravel and clay, graded from the hillsides, together with a miscellaneous collection of junk of all descriptions, filled in on low ground. On this miscellaneous subgrade a foundation of broken brick, crushed stone, broken concrete debris and other coarse aggregate material was placed at a varying thickness ranging from two to eight inches. This was compacted thoroughly. On the aprons and runways is a three-inch layer of crushed rock, ranging from three-quarters of an inch to one and one-half inches. This was shaped and rolled thoroughly, after which there was applied one gallon of asphalt emulsion per square yard by means of a pressure distributor. The surface then was covered with half-inch crushed stone chips sufficient to fill the voids and the whole again was thoroughly rolled, after which a second gallon of asphalt emulsion was applied. This was covered with crushed stone chips three-eighths to five-eighths of an inch in size and thoroughly rolled. The circular area at the hub of the runways is 300 feet in diameter but, unlike the runway area, it has been treated with road oil. The soil underlying the circular area is composed mostly of sand and gravel. There is an excellent emulsified asphalt macadam service road at this Glenn Curtiss field.

United States Naval Air Station, San Diego, Calif. "Mixed-in-Place" Asphalt Construction for the Runways, Asphaltic Concrete for Taxiways and Bituminous Macadam for Aprons were the Types of Surfacing Adopted at this Airport.

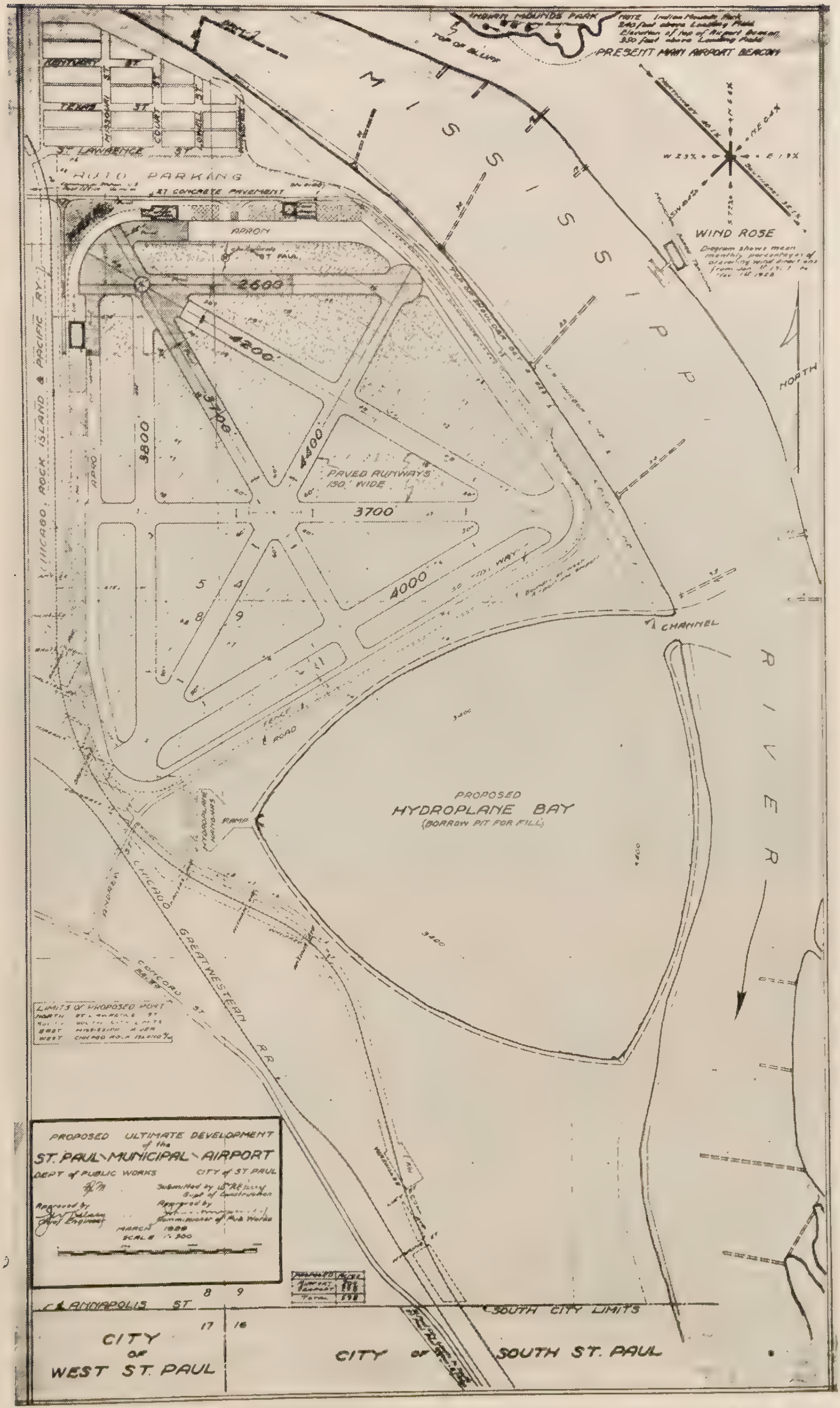
### Emulsified Asphalt Used at Roosevelt Field.

Roosevelt Field, at Mineola, also on Long Island, has runways constructed in a manner somewhat similar to those at the Glenn Curtiss field. The top course of the runways is two and one-half inches thick and consists largely of crushed rock, graded from one and one-half to three-quarters of an inch. The rock was rolled thoroughly before any bituminous material was applied. Emulsified asphalt, in the amount of one gallon to the square yard, was applied through a pressure distributor, which dragged two spike-toothed harrows behind it. This course then was rolled with eight and ten-ton tandem rollers and three-quarters of a gallon per square yard of emulsified asphalt was applied. This was covered immediately with half-inch crushed gravel and thoroughly rolled. A second application of one gallon of emulsified asphalt then was applied and covered with gravel grits which were broomed carefully and rolled into the surface. A final application of one-fifth of a gallon per square yard of emulsified asphalt was applied after a few days.

The King County airport at Seattle, Wash., is known as Boeing Field. Some of the warming up aprons are of Portland cement concrete and some are of bituminous treated slag. The runways are of slag which was bladed and rolled and then oiled. These runways handle fairly heavy traffic and appear to be standing up well in service. The slag was spread just prior to being rolled and oiled.

LANDING FIELD AT PORT COLUMBUS AIRPORT AS SEEN FROM THE ROOF OF THE ADMINISTRATION BUILDING. THE PLANES ARE STANDING AT THE EDGE OF THE PAVED AREAS.

The Naval Air Station at San Diego, Cal., is another excellent airport. Details as to the methods of construction there are lacking, but the following information was reported: This station is for both land and water planes. At present it has 96,700 square yards of runways mixed in place with road oil at a cost of 31 cents per square yard. It has taxiways, aggregating 39,500 square yards in area and costing 71 cents per square yard, that were constructed of cold-mixed asphaltic concrete and macadam. It has 56,900 square yards of warming-up aprons that were con-


INDIAN MOUNDS PARK
NOTE Indian Mounds Park 240 feet above Landing Field. Elevation of top of Airport Beacon 330 feet above Landing Field
PRESENT MAIN AIRPORT BEACON
TOP OF BLUFF
KENTUCKY ST
TEXAS ST
ST. LAWRENCE ST
AUTO PARKING
27 CONCRETE PAVEMENT
APRON
MISSISSIPPI RIVER
W 23%
E 19%
NE 6%
WIND ROSE
Diagram shows mean monthly percentages of prevailing wind directions from Jan. 1st 1921 to Nov. 1st 1928
NORTH
TOP OF SHOULDER
2600
4200
3700
3800
4300
PAVED RUNWAYS 150' WIDE
3700
4000
CHICAGO, ROCK ISLAND & PACIFIC RY.
CHANNEL
ROAD
FENCE
PROPOSED HYDROPLANE BAY (BORROW PIT FOR FILL)
RAMP
HYDROPLANE HANGARS
CHICAGO GREAT WESTERN RR
CONCORD ST
LIMITS OF PROPOSED PORT
PROPOSED ULTIMATE DEVELOPMENT of the ST. PAUL MUNICIPAL AIRPORT
DEPT of PUBLIC WORKS
CITY of ST PAUL
Submitted by Supt of Construction
Approved by Chief Engineer
Approved by Commissioner of Pub. Works
MARCH 1929
SCALE 1" 300
ANNAPOLIS ST
SOUTH CITY LIMITS
CITY OF WEST ST. PAUL
CITY OF SOUTH ST. PAUL

Map, Showing Proposed Ultimate Development of the Municipal Airport, St. Paul, Minn.

structed of concrete and bituminous macadam at a cost of $1.38 per square yard and 14,000 square yards of service roads of Portland cement concrete that cost $2.00 per square yard.

Lambert Field at St. Louis, Mo., has 128,000 square yards of runways that were mixed in place with about 50 per cent of crushed rock to stiffen the mix. Road oil and cut-back asphalt were used as the cementing agents. This has resulted in high-type heavy-duty runways at a cost of $1.05 per square yard. Directly in front of the Portland cement concrete aprons are 80,000 square yards of oil-treated surfacing which cost 9 cents per square yard. This surface has proved so satisfactory during the past year that it is intended next year to oil-treat similarly the triangles lying on each side of the triangle that already is oil-treated. Three-quarters of a gallon of road oil and three and one-half gallons of cut-back asphalt per square yard were used on the runways.

RUNWAY CONSTRUCTION WORK AT ST. PAUL MUNICIPAL AIRPORT. INITIAL "ROLLING" OF "BLACK BASE" RUNWAY ON A SAND-FIELD SUBGRADE BY MEANS OF A FIVE-TON TRACTOR.

### ASPHALTIC CONCRETE USED AT SAN FRANCISCO.

The San Francisco Bay Airdrome is an airport that originally was low and marshy. It was filled by hydraulic dredging. The fill largely was of a silty material which did not form an entirely satisfactory subgrade. The present development includes two runways with 53,000 square yards of hot-mix, coarse-aggregate asphaltic concrete on a base of six inches of oyster shell, compacted by rolling. The oyster-shell base was untreated. The advantage of this type of surfacing under the soil conditions existing at this San Francisco airport has been well demonstrated there. Since the original paving was laid last year certain portions of the airport areas have settled from eight to ten inches. Due to the type of surfacing used it was possible to keep the runways in service at all times, the original grades being gradually reestablished by the addition of bituminous treated materials. An exceptionally satisfactory non-skid surface has been obtained on the runways.

At Columbus, Ohio, special attention also was given to obtaining a non-skid runway at Port Columbus. The runways and loading platform were constructed with a five-inch Portland cement concrete base and one and one-half inch, hot-mix, coarse aggregate, asphaltic concrete surface course. A total of 90,000 square yards of this type of pavement were laid at a cost of $1.25 per square yard.

Runway Construction Work at the St. Paul Municipal Airport. Close-Up View Showing Nature of Initial Compression on "Black Base" Runway. Made with a Five-Ton Tractor.

### Runways at the St. Paul Airport.

Somewhat similar runways were constructed at the St. Paul, Minn., airport. The St. Paul airport is located in a bend of the Mississippi River within a stone's throw of the downtown business district. Extensive hydraulic filling was necessary in order to bring the airport surface above the high-water level. Two million cubic yards of hydraulic fill, ranging from three feet to fifteen feet in depth, already have been placed. The fill is a coarse river sand. The runways have been constructed directly on the hydraulic fill.

The runways are 150 feet in width and are constructed of three-inch hot-mix "black base" and a surface course, two inches thick, of hot-mix asphaltic concrete. Asphalt of 100 penetration was used. The surface course was covered with one-half gallon per square yard of cut-back asphalt. Granite chips immediately were spread over the surface and dragged and broomed. The chip course then was sealed with two-tenths of a gallon of cut-back. The result is a surface entirely closed but, at the same time, absolutely non-skid. We used "black base" on one of the runways. Considerable difficulty was experienced at first in placing the "black base" on the loose sand fill. All sorts of rollers were tried, tandem and three-wheel, and from one to twelve tons, without any success whatever. A five-ton caterpillar tractor then was employed to make the first pass over the base after the raking. This method proved surprisingly successful. There was no shoving of the base ahead of the tractor as occurred when rollers were used to make the first pass.

### READY FOR PROGRESSIVE CONSTRUCTION.

The most surprising feature noted in the "black base" procedure was, that while rollers could not be used to make the first pass, ten and twelve-ton tandems were operated over the base immediately following the first pass of the five-ton caterpillar tractor. The layout of the St. Paul airport is interesting. The design was adopted over two years ago and has been adhered to religiously since adoption. The plan shows the possibilities for almost indefinite expansion for future air traffic. As the need for expansion develops the airport can be enlarged through progressive steps without interruption in the use of the airport. A vision of the appearance of a busy airport in the future was indicated at the Curtiss-Reynolds Airport near Chicago, Ill., last fall during the national air races when

RUNWAY CONSTRUCTION WORK AT ST. PAUL MUNICIPAL AIRPORT. "BLACK BASE" RUNWAY AFTER FINAL COMPACTION WITH ROLLERS.

scores of planes were in the air at times. The runways at the Curtiss-Reynolds field also are bituminous treated.

The results of our survey of about two years of airport surfacing and paving show clearly that bituminous materials have played a big part in the surfacing that is now in place and are destined to play a bigger part in future work. There appear to be few airports where traffic is so heavy that a runway pavement is necessary and, conversely, there are few airports where some kind of runway surface treatment is not essential to the success of the airport. Our survey has brought out the fact that in the big majority of cases satisfactory runways can be developed through a bituminous surface treatment of some kind.

### HEAVY PAVEMENTS NOT NECESSARY AT AIRPORTS.

Heavy pavements, with heavy costs, are not necessary at present. The trend distinctly is away from turf, away from heavy pavements and toward bituminous surface treatment for runways. This is the one important fact developed by our survey and, if properly recognized, it will be the big factor to contribute toward obtaining more and better airports. And, as quoted at the outset of this report, "The importance of more and better airports cannot be stressed too strongly; for, upon the creation and maintenance of numerous and well equipped airports the aviation industry must depend for its future development." In a successful aviation industry the asphalt paving industry is destined to find a giant customer for its products.

AIR VIEW OF THE ST. PAUL MUNICIPAL AIRPORT, SHOWING ASPHALT RUNWAYS, APRONS AND LANDING AREAS.

## APPENDIX.

### LIST OF AIRPORTS REPLYING TO AIRPORT SURFACING QUESTIONNAIRE.

**ALASKA**
43. Fairbanks

**ALABAMA**
35. Mobile

**ARIZONA**
38. Flagstaff
100. Nogales
128. Prescott

**ARKANSAS**
73. Monticello

**CALIFORNIA**
116. Banning
113. Calipatria
37. Eaglewood
99. El Centro
76. Fresno
86. Long Beach
66. Los Angeles
72. Los Angeles
67. Presido of San Francisco
54. San Diego
63. San Francisco
81. San Francisco
57. San Pedro
61. Santa Barbara
68. Santa Monica
62. Sebastopol
60. Selma
114. Trona

**COLORADO**
125. Colorado Springs

**CONNECTICUT**
40. Bridgeport
7. New London

**DISTRICT OF COLUMBIA**
32. Washington

**DELAWARE**
74. New Castle

**FLORIDA**
65. Clearwater
109. DeLand
96. Pensacola
98. Stuart

**GEORGIA**
108. Jefferson

**IDAHO**
84. Boise

**ILLINOIS**
18. Bellville
49. Chicago
14. Glenview
29. Marion
23. Rantool

**INDIANA**
31. Bedford
64. Fort Wayne
1. Hobart
121. La Porte
22. Richmond

**IOWA**
75. Cedar Rapids

**KANSAS**
127. Eldorado
12. Ft. Leavenworth
11. Kansas City
69. Wichita

**KENTUCKY**
118. Lexington
27. Louisville

**LOUISIANA**
132. Baton Rouge

**MAINE**
10. Bangor

**MASSACHUSETTS**
110. Beverly
39. Boston
58. Boston
106. Boston
6. Brockton
28. Fall River
112. Lawrence
50. Marlboro
2. Mendon
101. Quincey
43. Springfield
8. Worcester
131. Ayer

**MARYLAND**
None

**MICHIGAN**
30. Ann Arbor
56. Dearborn
117. Gaylord
44. Lansing
59. Pontiac

**MINNESOTA**
19. Minneapolis
82. St. Paul

**MISSISSIPPI**
None

**MISSOURI**
52. Hagerstown
3. Jefferson City
20. Kansas City
79. Kansas City
77. St. Louis
26. St. Joseph

**MONTANA**
5. Helena

**NEBRASKA**
None

**NEVADA**
78. Reno

**NEW HAMPSHIRE**
104. Claremount
55. Concord
80. Keene

**NEW JERSEY**
129. Atlantic City

**NEW MEXICO**
47. Deming
25. Miles City

**NEW YORK**
126. Glen Falls
94. Kingston
71. Malone
115. Sunmount
21. Syracuse
85. Valley Stream, L. I.
133. Rochester

NORTH CAROLINA
45. Pinehurst
53. Shelby
95. Wilmington

NORTH DAKOTA
122. Jamestown
24. Lakeville
33. Towner

OHIO
15. Akron
111. Camp Perry
16. Cincinnati
102. Cleveland
51. Columbus
91. Dayton
92. Springfield
107. Zanesville

OKLAHOMA
None

OREGON
36. Portland
83. Salem

PENNSYLVANIA
4. Bethlehem
120. Clearfield
41. Morristown
124. Philadelphia
17. Pittsburgh

RHODE ISLAND
None

SOUTH CAROLINA
103. Seneca

SOUTH DAKOTA
123. Vermillion

TEXAS
105. Austin
88. Beaumont
90. Brownsville
13. Dallas
105. Austin
119. Denton
87. Galveston
97. Port Arthur

TENNESSEE
None

UTAH
None

VERMONT
None

VIRGINIA
48. Dalgren
9. Lynchburg
46. Martinsville

WASHINGTON
89. Seattle
130. Vancouver Banks

WEST VIRGINIA
34. Martinsburg
70. Morgantown

WISCONSIN
42. Three Lakes

WYOMING
None

PANAMA CANAL ZONE
Balboa Heights,
C. Z.

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## DISCUSSION.

CHAIRMAN SKIDMORE: The conference is grateful for the very complete survey which Mr. Carey has so excellently reported. I believe Mr. Thompson is sitting out there. He was a member of this committee and if he has any remarks to make or anything to add we would be glad to hear it now.

MR. MARK R. THOMPSON, St. Louis, Mo.: I don't have any other remarks to make in that respect. In the last conference we covered the construction at St. Louis. If there are any questions along the line of our construction methods at St. Louis, I would be glad to answer them.

CHAIRMAN SKIDMORE: There being no further discussion in that respect we will proceed with the general discussion, led by Mr. A. T. Hague, engineer of the Standard Oil Company of Indiana, Chicago, Ill.

MR. A. T. HAGUE, Chicago, Ill.: Mr. Chairman and Gentlemen: This survey and report is valuable to engineers and airport officials, especially those who are contemplating the developing of airports in their community. An airport, like a highway, is an investment which is difficult to measure in dollars and cents. The progressive type of construction is a means of developing an investment as well as a pavement, while the completed pavement is necessary to meet an emergency and serve the needs of aviation in important air terminals.

The report which has been presented carefully points out just what the condition is, with respect to airport paving, both in magnitude and importance. The 2600 airports, with a requirement of 300,000,000 yards of paving, indicate that we all must get busy. The noted pilots on the program today stressed the importance of paving to aviation progress.

The fundamental types of construction in developing airport paving are not very numerous and I believe can be outlined as follows: (1) Bituminous treatment of existing soils for the purpose of stabilizing and waterproofing. (2) Addition of bituminous treated mineral aggregate either to treated or untreated soils (preferably the treated soils). (3) Surface treatment or surfacing of compacted mineral aggregates. (4) Complete construction of a compacted mineral aggregate base with a wearing course, to a finished thickness.

We hear much said about low cost improved roads and farm-to-market roads. It looks as though another appropriate slogan also is going to be in order, such as "Low Cost Improved Airport Paving for Aviation Development!"

CHAIRMAN SKIDMORE: It looks as though we probably will have to postpone discussion of the papers on "mixed-in-place" construction. In resuming our session after lunch the program will be started promptly and the discussion of these papers will take precedence over the presentation of other papers. That will be followed immediately by other papers in that section and then the regular afternoon program will be taken up. The next in order is the "Report of the Resolutions Committee," which will be presented by Mr. C. N. Conner of the American Road Builders' Association, who is acting for the chairman of that committee, Mr. A. K. Vickery of Denver, Colo.

# Report of the Committee on Resolutions

## By A. K. Vickery, Denver, Colo.

*Chairman*

We, your committee, beg leave to submit the following resolutions with the recommendation that they be adopted by this conference:

(1) *George Washington Bicentennial*

WHEREAS, the Congress of the United States has created a commission to arrange a fitting nation-wide observance of the two hundredth anniversary of the birth of George Washington in 1932, and,

WHEREAS, the commission so created, composed of the President of the United States, the Vice President of the United States, the Speaker of the House of Representatives, four members of the United States Senate, four members of the House of Representatives and eight citizens appointed by the President of the United States, is charged with the duty of planning and directing the celebration, and,

WHEREAS, the high purpose of the event is to commemorate the life, character and achievements of the most illustrious citizen of our republic, and to give every man, woman and child living under "The Stars and Stripes" an opportunity to take part in the celebration which will be outstanding in the world's history, and,

WHEREAS, the George Washington Bicentennial Commission, in desiring the full cooperation of the people of the United States has extended a most cordial and urgent invitation to our organization to participate in the celebration; THEREFORE, BE IT

RESOLVED, that the Ninth Annual Asphalt Paving Conference, The Asphalt Institute and the Association of Asphalt Paving Technologists, in convention assembled at Memphis, Tennessee, December 4, 1930, do hereby endorse the program of observance of the two hundredth anniversary of the birth of George Washington, to take place in 1932, do hereby accept with appreciation the invitation of the George Washington Bicentennial Commission and pledge these organizations to extend their earnest cooperation to the commission in all possible ways, so that future generations of American citizens may be inspired to live according to the example and precepts of Washington's exalted life and character, and thus perpetuate the American Republic; and BE IT FURTHER,

RESOLVED, that this resolution be incorporated in the official proceedings of this meeting and that a copy thereof be transmitted to the George Washington Bicentennial Commission at Washington, D. C.

### (2) *Highway Construction Abroad*

WHEREAS, the Highway Section, Bureau of Foreign and Domestic Commerce, United States Department of Commerce, in cooperation with the commercial attaches and trade commissioners of the bureau in foreign countries, The Asphalt Institute, American Road Builders' Association, U. S. Bureau of Public Roads, National Automobile Chamber of Commerce, Highway Education Board, and Highway Research Council, is engaged in a world-wide campaign to bring to the attention of the various foreign nations the advantages of good roads and the construction thereof with American technical assistance, machinery, methods and materials, and

WHEREAS, we believe the work being done by the Department of Commerce is most important to the American road building industry and that it is promoting American trade and increasing interest in modern methods of transportation—especially motor transportation,—improving the economic condition of various countries, promoting the free movement of international traffic and establishing greater good will, peace and understanding between nations; THEREFORE BE IT

RESOLVED, that the Department of Commerce be urged to continue to provide means of collecting and disseminating important statistics and data on foreign highways, in order that the members of the Ninth Annual Asphalt Paving Conference, The Asphalt Institute and the Association of Asphalt Paving Technologists, as well as all others interested, may be kept fully advised at all times as to the status of highway development, both at home and abroad.

### (3) *Studies of Street and Highway Improvements*

WHEREAS, experience has shown that monies cannot be utilized economically in such enormous amounts as are now being appropriated and expended for street and highway improvement without adequate studies, followed by comprehensive plans, and,

WHEREAS, such plans must be followed by adequate financial and construction programs, in order to conserve the financial and material resources and to insure the greatest benefit to all taxpayers, and,

WHEREAS, experience has shown that such plans can be made and, when based on comprehensive transport and other surveys, in cooperation with Federal, state, county and other political subdivisions, can be utilized to insure more adequate transportation service and also to insure marked benefit to the taxpayers, and,

WHEREAS, experience has shown that the carrying out of such plans is insuring greater safety in vehicular operation, greater economy of vehicular operation and transportation costs, greater economy in time between objectives, increased pleasure of driving, coordination of plans for further growth and development and coordination of plans for grade-crossing elimination, and,

WHEREAS, such surveys and plans must include all areas, rural as well as metropolitan, so as to be fully and completely effective; THEREFORE, BE IT

RESOLVED, to recommend that the Federal Government, in cooperation with state, county and other existing political subdivisions, take a more active participation in the promotion and preparation of such surveys and the subsequent development of comprehensive plans for a more adequate transportation system.

### (4) *Farm-to-Market Roads*

WHEREAS, there are, at present, more than 2,000,000 miles of unsurfaced or inadequately surfaced, farm-to-market highways, and,

WHEREAS, this existing condition is a serious handicap in the economic progress of our nation, owing to excessive transportation costs and the consequent reduced purchasing ability of twenty-seven per cent of the people of our nation, and,

WHEREAS, low cost surfaces offer the most direct and immediate means of relief within the limits of the funds which can be economically justified in view of this vast mileage; THEREFORE, BE IT

RESOLVED, that the Ninth Annual Asphalt Paving Conference and its individual attendants, pledge support to Federal, state and county activities looking toward increased construction of such low cost road surfaces as will most economically satisfy the traffic demand.

### (5) *Dissemination of Facts*

WHEREAS, the inadequate dissemination of known facts regarding the economic construction and maintenance of low cost roads is seriously retarding the development of adequate transportation facilities in rural communities; THEREFORE, BE IT

RESOLVED, to encourage The Asphalt Institute and other agencies to devise ways and means to afford a wider dissemination of the best present practices for the construction and maintenance of low cost roads; and BE IT FURTHER

RESOLVED, that this conference encourage more economical administrative practices in connection with highway programs.

### (6) *Simplification and Standardization of Tests*

WHEREAS, so-called low cost roads are now being constructed in all parts of our country and in other countries, and

WHEREAS, the mileage of this type constructed annually is increasing at a greater rate than that of any other type, and

WHEREAS, there is a very apparent need for simplification and standardization of tests for the bitumen commonly used in these types in order that economies may be effected and understandable information may be exchanged between users of these bitumens, and

WHEREAS, these facts have been brought before the industry from time to time with little action taken thereon by it, and

WHEREAS, simplification and standardization of tests for other bitumens have effected real economies, and

WHEREAS, the Bureau of Public Roads, the several state highway departments, the Highway Research Board, American Road Builders' Association and others have recognized this urgent need and are now striving to accomplish these desirable results; THEREFORE BE IT

RESOLVED, that the Ninth Annual Asphalt Paving Conference and The Asphalt Institute heartily endorse all such efforts towards standardization and simplification and through their membership and staff and their affiliations and contacts will render every possible assistance in standardizing and simplifying tests for the materials, names of types, methods of construction and maintenance and equipment used therefor.

### (7) *Resolution of Thanks*

WHEREAS, the management of the Hotel Peabody has been most diligent, courteous and obliging in caring for this conference, making our stay in this hospitable institution a most enjoyable one, and

WHEREAS, Mayor Watkins Overton of Memphis, along with numerous officials of the city administration, with City Engineer W. B. Fowler, in particular, serving as chairman of the local arrangements committee and assisted by H. S. Reed, E. H. Cannon, C. L. Williss and others, as chairmen of special committees, by untiring effort, have contributed mightily to the success of this meeting, and

WHEREAS, the officers and staff of the Memphis Chamber of Commerce, particularly C. M. Anderson, executive vice-president; R. E. Logsdon, director of the convention bureau, and J. C. Ottinger, Jr., director of publicity, have left nothing undone in the way of extending cooperation and courtesies to those charged with organizing and conducting this meeting, and

WHEREAS, the Governor of Tennessee, Hon. Henry H. Horton, and the officials of the State Highway Department, led by State Highway Commissioner R. H. Baker and State Highway Engineer T. C. McEwen, have contributed much of their time and effort to making our visit to this state a most enjoyable and profitable occasion, and

WHEREAS, Mrs. W. B. Fowler and her ladies' committee, charged with entertaining the ladies present at this conference, have done so much to make the visit of the ladies a pleasant one that will be long remembered, and

WHEREAS, Colonel John H. Jouett, Major J. H. Doolittle and Captain Frank M. Hawks, noted aviators and distinguished officers, have not only honored this conference with their presence and appeared on our program, but have clearly demonstrated that aviation is destined in the future to be widely adopted as a most rapid and advantageous mode of travel to and from conventions for those with such limited time that they otherwise could not attend, and

WHEREAS, numerous public officials, engineers and technologists from all parts of this country and Canada, as presiding officers and speakers, have contributed of their knowledge and experience in providing for us a most instructive program of discussion and have given us much valuable information that can be applied in our own work at home; THEREFORE, BE IT

RESOLVED, that the thanks of this conference, be and are hereby extended to all of those above mentioned, as well as to the press of Memphis and the citizens of this city in general, for the cordial treatment accorded us during the week that we have spent in this enterprising and thriving metropolis of the South.

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CHAIRMAN SKIDMORE: Gentlemen, you have heard the resolutions read.

A DELEGATE: I make a motion that the resolutions be adopted as read.

The motion having been seconded and put to a vote, was carried.

CHAIRMAN SKIDMORE: The resolutions are adopted as read. Now, I believe Mr. Hubbard has some announcements to make.

MR. PREVOST HUBBARD of New York: I feel sure that the subject of "mixed-in-place" construction is of tremendous interest to all of you gentlemen and I believe there are many points which should be developed in the discussion this afternoon clarifying particularly some misconceptions that occur because of the fact that the term "mixed-in-place" is used to describe two distinct types of construction.

I have also to announce that a list of the delegates to this convention has been made up and may be seen at the registration desk. This list will be printed and mailed at a later date to all attending this conference.

Mr. Howe, of the Memphis engineering department, has some maps showing the city paving types, which are available upon request.

The conference has received numerous telegrams and letters from the public officials of various cities extending invitations to hold the Tenth

Asphalt Paving Conference next year in their cities. The cities which have communicated with the conference are: Montreal, Toronto, Atlanta, Cincinnati, Detroit, Grand Rapids, and Houston. These communications will be handed to the stenographer and recorded and the matter will be considered at a future meeting of the Board of Directors of The Asphalt Institute.

CHAIRMAN SKIDMORE: There being no further business, the meeting will be adjourned until two o'clock.

# FIFTH SESSION

## HOTEL PEABODY, 2 P. M., THURSDAY, DECEMBER 4, 1930

*(Joint Session with the Association of Asphalt Paving Technologists)*

## PREVOST HUBBARD, PAST PRESIDENT, THE ASSOCIATION OF ASPHALT PAVING TECHNOLOGISTS, PRESIDING

CHAIRMAN HUBBARD: Gentlemen, the meeting will now come to order and, as announced at the close of the morning session, this meeting will open with a discussion of the two papers on "mixed-in-place" construction presented by Mr. Pauls and Mr. Spelman. I mentioned this morning that considerable misunderstanding has resulted from a lack of uniformity in the application of the term "mixed-in-place" construction. "Mixed-in-place," as used by the eastern engineer, means quite a different type of construction from "mixed-in-place" as used by the western engineer. Of course there are many engineers who realize the basic difference but there are many who do not.

I have in mind two construction jobs that I saw last spring in which the eastern type of aggregate was used with the western type of bituminous material, with results which were far from satisfactory and due apparently to a misunderstanding on the part of the engineer as to what the proper relationship of the aggregate and bituminous material should be. In the western type of construction a graded aggregate, running from the coarsest size down to and including the 200-mesh material, in substantial quantity, is used. In the eastern type of construction, such as is illustrated by Mr. Spelman's paper, an aggregate which is practically a single commercial crushed stone product is used. That is to say, practically all material under one-quarter of an inch in diameter has been removed in its production.

These two types of aggregate require entirely different types of bituminous material in order to produce satisfactory mixtures. With the western type of aggregate a non-volatile oil has been used to a great extent. If a cut-back oil is used it should be relatively slow in curing. If such material is used in connection with the eastern aggregate the mixture does not harden with sufficient rapidity to produce a stable wearing course. It works out very satisfactorily, however, with the graded material, which may be bladed a long time after application. On the other hand, the eastern type of aggregate requires the use of a more rapid curing product and one that will harden with considerable rapidity. After mixing the eastern type of aggregate the road is rolled. The western type of aggregate used with the slow curing product is not rolled. If a bituminous material suitable for the eastern type is used with the western type of aggregate, which is graded, then the material sets up so fast that it is impossible to work it properly with the blade.

I think this difference should be clearly understood and any discussion leading to a clearer understanding, with a suggestion as to modification of existing terminology by name, would be very desirable. I am frank to say I have no very good suggestion to make in that connection. It is a matter which the engineers themselves should work out. I should be glad to have all of you who are interested in a discussion of this subject participate, but because our time is limited it will be necessary to limit each discussion to not more than five minutes. Gentlemen, the subject is open for discussion. Can't we stir up some discussion on this subject?

MR. H. C. HEADLEY, Montgomery, Ala.: I would like to ask one question in regard to the graded aggregate: Can you use with your western method a sand and gravel that has practically no clay?

CHAIRMAN HUBBARD: I am going to ask Mr. Pauls to answer that question, if he will.

MR. J. T. PAULS: I understand that question was whether the graded aggregate, from three-quarters to an inch, should contain clay?

MR. HEADLEY: Yes.

MR. PAULS: It should not contain clay. Clay is considered objectionable in the western aggregate for the oil-mixed type of construction. The test they make on the aggregate — the swelling test as it is called — is made to determine to some extent whether or not it has clay. The western aggregate is brought up to pass the three-quarters. In some cases it runs all the way down to ten per cent of the material passing the 200-mesh. This 200-mesh material should be rock material and not clay, although on old macadam and stone traffic-bound roads there is a considerable amount of clay in the surface, obtained in scarifying where the material in the old road is used in building the oil-mixed surface. For that reason, in some states, or all states, it is considered more desirable, although it may cost considerably more, to add new material. By that we will make sure that we will not have clay in the aggregate for that type of construction.

CHAIRMAN HUBBARD: Any further discussion? Are there any of the gentlemen here from North Dakota who have had experience with this type of construction and who would like to add a few remarks? I had hoped that this discussion would lead to a consideration of the relative advantages and disadvantages of the premixed variation in the "mixed-in-place" type of construction. There is much to be said for both methods, and in some cases I believe, as Mr. Pauls pointed out, that the premixed method is as economical, or more economical, than the "mixed-in-place" method. Mr. Baskin, would you care to make any remarks about the two methods of using the aggregate?

MR. C. N. BASKIN, Montreal, Canada: I think the matter is so involved that I could not give any definite information. It would seem, however, that a consideration of the various factors that contribute to the stability of these low cost mixtures and to a careful control of the premixed is a question of different situations. I do not think that at this time I could say anything more.

MR. J. T. PAULS: I might add, in connection with the comparison and use of plant-mixed and machine-made "mixed-in-place," that the practice in California at this time is to plant-mix in all new construction where the aggregates are to be added in, and, in such cases where they scarify either to obtain all the material or a portion of the material, the "mixed-in-place" type of construction or method is used. That seems to be the policy out there and they get it plant-mixed for about the same price that they can get the process mix.

CHAIRMAN HUBBARD: Any further discussion? If not, gentlemen, we will proceed to the next paper on "The Use of Asphaltic Materials for 'Mat' or 'Carpet Coat'," by Mr. H. C. Weathers, testing engineer of the State Road Department of Florida.

# The Use of Asphaltic Materials for "Mat" or "Carpet Coat"

**By H. C. Weathers, Gainesville, Fla.**

*Testing Engineer, Florida State Road Department*

The great demand for good, all-weather roads is too well known to discuss and the question of financing road programs by the various municipalities, counties, states and the nation as a whole, to serve all the people, is a problem of enormous magnitude. The American Farm Bureau Federation advises that there are, in the United States, 2,484,822 miles of unimproved dirt roads and many more miles of dirt roads with only slight improvement in grading and drainage. The present and future construction of main highway systems will increase the demand for lateral connecting roads, sometimes referred to as farm-to-market roads, in excess of the above figure. It is a financial impossibility to construct all of these roads with major-type pavements and even though the money were available the expenditure would not be justifiable as the traffic requirements are not sufficiently great to warrant high-type pavements. On the other hand, the dirt or earth roads will not carry present day vehicles in all kinds of weather. Therefore, a low cost pavement is necessary. This necessity has been realized by all concerned in road building and practically all the interested organizations have made rapid progress in developing low cost types of road surfacing to meet this demand.

It is a recognized fact that dirt, top soil, sand-clay, shale, macadam, gravel and roads of similar nature will not give economical service under present day, fast moving traffic but it has been proven that by various treatments of these roads with asphaltic materials a low cost, year-round surface can be obtained. Treating roads with asphaltic oil is not really a new development, as California used asphaltic oil in road treatment over thirty years ago, but it has been only recently that the engineers have discarded the haphazard methods of the past and realized that the asphaltic treatment of roads is of sufficient value to warrant as much scientific and intelligent study as is required on the more expensive types of pavement. In recent years, from a careful study of using asphaltic oils on various types of roads and test data accumulated from laboratory tests and actual field experiments, specifications have been written and great progress is now being made in developing the low-cost road by the use of asphaltic materials.

### RESEARCH PLAYS IMPORTANT PART.

The research fields, at the present time, are very broad. They cover the nature of the soil, drainage, kind of oil and the nature of the cover material. In addition to the research work on materials, much work is being done in an experimental way on the method by which the bituminous and cover materials are applied and the manner in which the roads are constructed and maintained.

LIMEROCK ROAD READY FOR SURFACE TREATMENT. FLORIDA STATE HIGHWAY DEPARTMENT.

The intent of this paper is to consider one of the many types in which asphaltic oil is used to improve low-type roads. This type is the *"Mat"* or *"Carpet Coat"*, which is separate and distinct from the oil surface treatment that is used primarily as a dust preventative. It is also separate from the asphaltic construction courses of a greater thickness than approximately one-half to three-quarters of an inch. Due to the fact that different localities use a different name for practically the same type of construction, it will be referred to in this paper as the "mat", "carpet coat", or "surface treatment."

The true bituminous "mat" or "carpet coat" should possess at least three essential characteristics. It should, first of all, be thoroughly bonded to the underlying surface. Secondly, it should be stable, so as not to corrugate or shove under traffic owing to internal movement. Third, it should waterproof the underlying road from surface absorption. The "mulch treatment," more commonly known as "mixed-in-place" bituminous construction, does not exactly come under the "mat" or "carpet coat" type, and as this subject is to be discussed next on the program, I will not include it in this paper. "Mats" or "carpet coats" can be applied successfully to certain roads in certain localities. This has been demonstrated by various states. The types of bases on which it has been applied are numerous, and include soil roads, sand-clay, gravel, waterbound macadam, stone, shale, etc., but in all cases it should be understood that the life of a "mat" is largely dependent upon the support afforded it by the underlying structure. It will be unsatisfactory and failures may be expected where inadequate drainage occurs and also when laid over structures which lose their inherent stability at any period of the year, due to the rise of capillary moisture. Some soils, for instance, while highly capillary in character, are, nevertheless, stable when they contain a high percentage of capillary moisture. Other soils and aggregates may become quite unstable, due to capillary absorption. In regard to this, there is a great field for laboratory work in analyzing soils in advance of proposed construction and determining the suitability of the soil under varying moisture conditions and their respective load supporting qualities.

Prime Coat as Applied to Limerock Road at the Rate of One-Fourth Gallon to the Square Yard. Florida State Highway Department.

## Value of Good Drainage Structures.

Drainage is a very important item in this type of construction; even more important than in the construction of higher type pavements. No road, whether it be the lowest type of natural soil, or the highest type, will prove satisfactory unless properly graded and drained. Answers to questionnaires sent to different localities throughout the United States disclosed that all states were using practically the same construction methods in their "mat" or "carpet coat" construction, except slight minor variances necessitated by local conditions, such as available materials, climate, etc. From the data received, the use of bituminous materials in "mat" or "carpet coat" construction can be classified in three general groups, namely: Group No. 1, which includes "mixed-in-place" or "retread" construction; Group No. 2, surface treatments, applied in single or double applications and not mixed after being placed, and Group No. 3, oiled earth roads.

From data at hand state highway departments and municipalities using the "mat" or "carpet coat" construction as mentioned above are shown to be as follows:

Group 1. Missouri, Ohio, South Carolina, Wyoming, Indiana, Florida, West Virginia, Minnesota, Nebraska, Oregon, Kentucky and California.

Group 2. City of Des Moines, Iowa; South Carolina, North Carolina, Virginia, Lake County, Ohio; Massachusetts, District of Columbia, City of Denver, Indiana, New York, Pennsylvania, West Virginia, Georgia, Oregon and Florida.

Group 3. Tulsa County, Oklahoma; several counties, townships, cities and villages in Illinois and, to some extent, in North Carolina.

As Group No. 1 comes under the subject which is to be presented next

Applying Hot Asphalt Seal Coat to Limerock Road at the Rate of About Four-Tenths of a Gallon per Square Yard and Covering with Slag Chips. Florida State Highway Department.

on the program I will leave this type of construction to the next speaker. Group No. 2, in general, is a "mat" or "carpet coat" built upon a prepared base course of sufficient thickness to carry the expected traffic. It generally consists of a double application of bituminous material with a prime coat either of tar or asphaltic oil of low viscosity which is allowed to cure and then is covered with an application of asphaltic oil of a higher viscosity. This is covered immediately with from 40 to 50 pounds of crushed slag, stone or gravel and rolled. Sometimes sand is used as the cover material but, in most cases, crushed stone, slag or gravel is used. The coarse aggregate has proved to be more satisfactory than sand. Group No. 3, in general, is a bituminous "mat" built up on an earth road which has previously been put in shape for oiling. It is treated with varied applications of bituminous oil and covered with the existing earth material which has been scraped from the road, while preparing it for the oil treatment, or thrown in from the shoulders.

### NATURE OF THE CONSTRUCTION IN FLORIDA.

I do not wish to burden you with the details of construction. Therefore, I will not attempt to give the details of each state's work as mentioned above. However, I would like to go into the details of the work done in the State of Florida by using bituminous materials in "mat" or "carpet coat" construction with which I am more familiar and which is very similar to the processes used by many other states. "Mat coats" have been placed on the following bases with excellent results; macadam, sand-clay, gravel, chert, shale, limerock and, in some cases, top soil, or old cracked bituminous pavements and concrete pavements. In Florida, we are very fortunate in having an unlimited supply of soft limerock which, when placed on the subgrade to a depth of ten or eleven inches and watered and rolled to a compacted thickness of eight inches, makes an excellent base for the "mat" or "carpet coat." The majority of Florida roads are constructed with this material.

The State Road Department of Florida constructed its first limerock road, surface treated, in 1920. This was Road No. 5 across Levy County. The surface treatment consisted of a prime coat of tar, using approximately 0.2 gallon per square yard, followed with a second application of asphaltic oil, known as $OH_1$, applied approximately at 0.4 of a gallon to the square yard and covered with 40 pounds of slag uniformly graded from three-quarters to one-quarter inch with round-opening laboratory screens. The prime tar met the following specifications:

| | |
|---|---|
| Specific gravity 25° C/25° C | 1.100 to 1.140 |
| Specific viscosity at 40° C | 8 to 13 |
| Total distillate by weight: | |
| To 170° C | not more than 5.0% |
| To 270° C | not more than 30% |
| To 300° C | not more than 40% |
| Total bitumen (soluble in carbon disulphide) | not less than 90% |

The asphaltic oil met the following specifications:

| | |
|---|---|
| Specific gravity 25°/25° C | not less than 0.980 |
| Flash point | not less than 80° C. |
| Specific viscosity 100° C | not more than 60 |
| Float test at 32° C | not less than 60 secs. |
| Loss at 163° C.—5 hours | not more than 15% |

| | |
|---|---|
| (a) Float test of residue 50° C. | not less than 110 secs. |
| Total bitumen (soluble in carbon disulphide) | not less than 99.5% |
| Percent of total bitumen insoluble in 86° B. naphtha— | not less than 6.0% |

The results of this first project were so pleasing that the department continued the construction until about 1926, at which time it was found that a little heavier asphaltic material was necessary for summer work, as the bitumen was bleeding through the cover material and the surfaces were getting slick. The specifications for the asphaltic oil used in the second application were changed to the following, which is still being used:

| | |
|---|---|
| Specific gravity at 25° C. | not less than 0.99 |
| Flash point | not less than 100° C. |
| Specific viscosity 150° C. | 7.5 to 20 |
| Float test at 50° C. | not less than 100 secs. |
| Loss at 163° C—5 hours | not more than 7.5% |
| (a) Float of residue at 50° C | not less than 110 secs. |
| Bitumen soluble in carbon disulphide | not less than 99.5% |

A summer and winter viscosity was considered desirable and the specifications were made to read that for summer the viscosity should approximate 15 and for winter it should approximate 8 to 12. By changing the asphalt oil to a heavier grade it was necessary to apply 0.5 of a gallon instead of 0.4 as had been applied previously.

### Coarser Cover Material Now Used.

Our surface treatments have given excellent service over the last ten-year period. The only fault that we have been able to find is that after a few years the asphalt comes up, forms over the cover material and creates a slick surface. To eliminate this we have recently gone to a coarser cover material and we believe that it will correct the trouble. We are now using square-opening sieves for testing and the grading requirements for the cover material is:

| | |
|---|---|
| Passing 1″ sieve | 100% |
| Passing ¾″ sieve | not less than 90 |
| Passing ½″ sieve | 20 to 60 |
| Passing No. 4 mesh | 0 to 10 |

To get a more uniform distribution of cover material and also a thicker "mat", we are conducting several experiments by using stone, slag and crushed gravel and dividing the material into two sizes, coarse and fine. By applying the coarse material first, at about 35 pounds per square yard, then hand-spotting or choking with the fine material, at about 15 pounds per square yard, and brooming before rolling, we are obtaining a more uniform "mat" and one which we do not believe will bleed or get slick as it is a thicker "mat" and holds more of the aggregate than when applied in the old way. This is especially true with our local stone, which is a much softer cover material than slag or gravel. All three types of cover material are used. Another experiment is also being carried on with the idea of improving the "mat". This consists of applying the cover material as described above and using a double application of the asphaltic oil. This is giving a thicker "mat." The final results of these experiments and the cost of same are not available at this time.

In constructing the above type of "mat" or "carpet coat" the finished base is broomed clean of all loose material either with rotary or hand brooms, or both, if necessary. The prime coat of tar or asphalt is applied with a pressure distributor at about 0.2 of a gallon per square yard. This is covered with sand to prevent traffic from getting into it and is allowed several days to cure. When weather conditions are suitable,—if cold, the operation is postponed until the weather is warm,—the prime coat is cleaned of all loose material by brooming and the asphaltic oil is applied hot between the temperatures of 200 to 250° F. by a pressure distributor. Immediately after the distribution of the oil the cover material is applied by hand, casting a portion of the material on and then spotting the balance by hand and brooming to obtain a uniform surface. Approximately 50 pounds per square yard of cover material is applied. After grooming, it is rolled with a ten-ton roller until the aggregate is keyed in place. We have had very good success with "mat coats" on sand-clay roads. The first construction of this nature was in 1927 and the same grades of materials were used as on the limerock work except that the amount of prime coat was increased to .35 of a gallon per square yard. On some of our sand-clay bases we have found it advisable to add about two cubic yards of pea gravel, spread over the surface of each one hundred linear feet of base, and to allow traffic to work this material into the surface of the sand-clay, with constant machining with a grader to keep the gravel distributed uniformly over the surface. This material adds stability to the surface of the sand-clay and greatly improves its quality.

CONSTRUCTING ASPHALT LIMEROCK ROAD IN FLORIDA. THIN PLACES ARE COVERED BY HAND FROM STOCK PILES. THOROUGH BROOMING MAKES FOR UNIFORMITY. FLORIDA STATE HIGHWAY DEPARTMENT.

### MILEAGE OF CARPET-COATED ROADS IN FLORIDA.

The State Road Department of Florida has constructed, to date, 1389 miles of limerock base with a bituminous "mat" or "carpet-coat" surfacing and 291 miles of the same surface on a sand-clay base. There is today 44 miles of rock base and approximately 30 miles of sand-clay under construction. I do not have the average total cost to date of all this work, but for a fair average, on the 291 miles of sand-clay that we have under maintenance this year, the maintenance cost per mile per month is $24 and, of this amount, approximately 25 per cent is chargeable to the surface. The remainder is the cost of maintaining right-of-ways, road-beds, structures, guard rails and signs. The department has under maintenance 1907 miles of rock base with "mat" surfacing. The difference between this figure and the miles constructed is due to the county roads that the department has taken over for maintenance. The average cost of maintenance this year on this mileage is $16.10 and of that approximately 25 per cent is chargeable to the surface and the remainder to the other items mentioned above. There is rather an interesting thing that our maintenance work this year has disclosed and that is that our surface maintenance on practically all types of roads varies but very little on types above sand-clay with "mat coat" treatments.

CONSTRUCTING ASPHALT LIMEROCK ROAD IN FLORIDA. ROLLING THE COVER COAT MATERIAL. WHEN SOFT LOCAL STONE IS USED A FIVE-TON ROLLER IS EMPLOYED. WITH SLAG OR CRUSHED GRAVEL, A TEN-TON ROLLER IS USED.

It is the opinion of the writer and other engineers with the State Road Department of Florida that the surface treatment work in this state has given excellent results and that this type of road has paid larger dividends, based on the monies invested, relative to the traffic carried, than any other type of road. The average cost of the "mat" or "carpet coat" on both the limerock and sand-clay bases is about $2200 per mile or, roughly, 19 cents per square yard. The average cost of limerock base construction is $1 per square yard. The amount of traffic using this type of road varies from a few vehicles per day on isolated projects to approximately 2000 per day on our more heavily traveled projects. When this type of construction was inaugurated it was the opinion of all concerned that a retreatment would be necessary every two or three years, but to date this has been unnecessary, as none of the projects have worn to where a retreatment was needed. Some projects have been retreated on account of becoming slick, but, by our recent experiments, we expect to eliminate this condition.

Close-Up View of Cover Coat on Florida Asphalt Limerock Road, Showing Texture of the Surface. The Rule is One Foot in Length.

We also have bituminous "mat" or "carpet coats" on old brick, or cracked asphaltic concrete and sheet asphalt pavements. Lake County, Ohio, has used this coat on old concrete pavements. I understand this method has been used by several states and cities to renew the life of their old pavements. South Carolina uses a method of applying a "mat coat" to old sleek bituminous surfaces in order to obtain non-skid effects which may be interesting. She has completed to date about 40 miles of this type of construction, which consists of an application of kerosene at one-twelfth of a gallon per square yard, covered with about seven pounds of three-eighths inch stone and rolled with a five-ton roller. The cost of this treatment is about $300 per mile. In the above mentioned groups of "mat" or "carpet coats," Group No. 3 included the oiling of earth roads. As the problem of constructing earth roads so as to be year-round, all-weather roads is getting to be such a huge problem I believe it would be interesting to know what others are doing in regard to this type of construction.

### Experience in Tulsa County, Oklahoma.

Mr. Stoner K. McLelland, county engineer at Tulsa, Oklahoma, has accomplished some very good results from oiling earth roads and I will briefly describe his methods, quoting Mr. McLelland as follows: "Two grades of oil are placed in competition with specifications as follows:

Asphalt base road oil, known as Tulsa County Standard No. 1. This road oil shall be homogeneous and shall not contain not to exceed one (1%) percent by volume of water and shall meet the following requirements:

| | |
|---|---|
| Specific gravity at 60°F | not less than 0.930 |
| Specific viscosity at 140° F (Engler) 50 cc | 10-30 |
| Flash point | not less than 200° F |
| Total bitumen soluble in $CS_2$ | not less than 99.5% |
| Ductility of asphalt at 77°F | not less than 14 cm. |
| Insoluble in 86° Baume naphtha | not more than 9.0% |
| Asphalt at 100 penetration | not less than 50% |

Paraffin base road oil, known as Tulsa County Standard No. 2.

Not more than one (1%) per cent by volume of water.

| | |
|---|---|
| Specific gravity at 60° F | not less than 0.920 |
| Specific viscosity at 60° C | 16.1 to 28.0 |
| Total bitumen soluble in $CS_2$ | not less than 99.5% |
| Flash point | not less than 93.3° C (200° F) |

When the specific gravity of the oil at 60° F is less than 0.975, the per cent of bitumen insoluble in 86° B paraffin naphtha shall not exceed 9.0%.

Asphaltic content—percentage of residue at 100 penetration—50 to 70%.

"Tulsa County, Oklahoma, being in the heart of the Oklahoma oil fields, readily took advantage of the application of oil to its lateral county highway system. Having pioneered the use of road oil in this section, much that we have learned has been from actual experience. In the past we had no specification for oil, but this year we adopted a standard specification on both asphalt-base and paraffin-base oil and asked for competitive bids from the refineries located in this field. At the end of the oiling season just closed, Tulsa County had approximately 250 miles of roads surfaced with asphalt-base oil and had used approximately *three million* (3,000,000) *gallons* of oil during the season. We have had many visits from county commissioners and engineers in this section of the country to inspect our oiled roads and oiling machinery. It is a great advantage to see the machines in actual operation. We have also had many written inquiries from other sections of the country. I should like to refer also to a brief article published in the May issue of *Public Works.*

"In condensed detail, I suggest the following procedure on a road that has never been oiled: First, the road should be put in as perfect condition as possible regarding grade and drainage before application of the oil begins. The first application is applied on a nine (9) foot strip, if an 18 foot width is desired, down the side of the road for at least one mile, with about three-quarters of a gallon of oil per square yard. Then the other side of the road should receive the same amount in the same manner. This method leaves the road open to traffic if the engineer thinks it necessary. However, a better condition would exist if the road were closed from one to seven days, depending upon weather conditions. After the first application has soaked into the soil, which generally takes from one to three days, the second coat should be applied in a like manner with about the same amount of oil. This procedure should continue throughout the extension of the road. The second coat depends upon the weather conditions. The sun forces the first application into the ground and the second coat of oil should be applied when the first coat has made its maximum penetration. This condition must be determined by the engineer on the job. The oil is applied at a pressure of not less than forty (40) pounds and a temperature of about one hundred and eighty (180°) degrees, to insure proper penetration.

A Completed Asphalt Surface Treated Limerock Road in Georgia. State Route No. 3 North of Albany. Constructed by the Georgia State Highway Department.

## Method of Treating Clay Soil.

"If the soil to be dealt with is a pure clay, I would recommend scarifying to a depth of two (2") inches and then pulverizing and blading to a smooth surface. This would give the required penetration. This type of soil is probably to be compared with what we call black gumbo—a gummy soil—encountered in some locations in Tulsa County, and we obtain very satisfactory results by this method. On other types of soil, such as sand and clay or sandy loam, it would not be necessary to use the scarifier.

In case sandy oil is encountered it might be advisable or necessary to apply a greater amount of oil than is used on other types of soil, due to the porous condition of the sand absorbing more oil. In sandy types of soil the oil may penetrate to a depth of five inches but after the first year's application of oil to a sandy road-bed it would not require any more oil than any other type of earth or soil. A drag can be used to good advantage in mixing the oil with the sand but it could not be used to any advantage on the other types of soil.

"The application of oil to an old gravel road is a matter of opinion among engineers. Only experience would tell to anyone the final result. With the experience I have had the result would be only a dust preventive and would not decrease the cost of maintenance, which is the result we are all seeking. More especially would this occur if applied on a gravel road of from five to nine inches depth. On this type of road the gravel, in all probability, will absorb a great percentage of the oil, thereby losing the more important factor that you are trying to secure, namely, a waterproofing. If oil is to be applied on this type of road I would suggest a thorough scarifying of the entire road-bed and blading the larger and loose gravel off of the road and wasting it, or it could be spread out on the shoulders, assuming an eighteen or twenty-foot width is to be treated.

### Oiling and Maintaining "Mats" on Gravel.

"In applying oil to a road that has been surfaced with maintenance or pea gravel at approximately five hundred tons per mile, the same preparations should be made as described in the preceding paragraphs,—blading all fine material to the shoulders and then blading back on the

A Road Constructed of Soft Limestone on a Clay Gravel Base. Then Surface Treated with Hot Asphalt. A Caddo Parish Road Near Shreveport, La. Constructed in 1925. The Picture, Taken in 1930, Shows Original Treatment Still in Excellent Condition.

road after the road is oiled. This would be a matter of opinion of the engineer in charge. With me, it would only increase the maintenance cost because the gravel will not have the penetration on oiled surface that it had on an earth surface and, therefore, will not seat itself in the road-bed. And having a tendency to move around and slide off as the traffic hits it, it would necessitate constant maintenance of the road.

### NATURE OF EQUIPMENT USED.

"The required results of oil on a road will not be so effective the first year of oiling as they will be in the following years and they need not be expected. Neither will the required results be secured on a newly graded road. A newly graded road will have a tendency to pit out more and break through more readily than an old or settled road-bed. We have several miles of road on a sand-and-clay base that were given one application of oil for four or five consecutive years and that, at the present time, have not been oiled for three years but are now in better condition than some of the roads that were oiled last year. These roads are still acting as a waterproofing as well as a dust preventive. Our roads secure no maintenance other than scarifying and blading back in shape twice a year and applying one application of oil at approximately three-quarters of a gallon per square yard, some time during the hot summer months. Scarifiers, with teeth spaced six inches apart, are attached to the graders. The condition of the earth road before and at the time the oil is applied plays a large part in the outcome or results of oiled roads. To secure the desired results, the road should be neither too wet nor too dry. If it is too dry and dusty, the dust and oil will ball up and collect in pockets and will be pulled out by traffic, leaving the road pitted.

"If heavy equipment for blading and scarifying is not owned or cannot be secured, holes can be filled by hand by shoveling some of the loose oiled earth that has collected from the run-off at the edges and placed in the holes. The traffic and heat will soon cement this with the road-bed. A hand spray can be used to a good advantage, placed on a man's back and carried down the road, spraying a small amount of oil in the holes before the oiled earth is shoveled in. Our equipment consists of eight 1,000-gallon-tank pressure distributors mounted on five-ton Liberty trucks, for the actual work of distributing the oil. However, a cheaper type of machine might be constructed with a gravity flow by mounting any ordinary sized tank on a lighter truck which could be dismantled at the close of the oiling season. I do not feel, however, that this type of machine would give proper penetration. Some of the preparations for oiling and the applications of oil, as well as the maintenance, greatly depend upon the wealth of the county as well as the equipment the county may have at hand. No doubt some counties could use whatever equipment they might have to a good advantage. I have given ideas where oil is used on a large scale."

### SUMMARY OF CONCLUSIONS.

Conclusions reached from a study of the existing data are summarized briefly as follows:

(1) That bituminous materials can be used successfully in "mat" or "carpet coats" in practically all parts of our country.

(2) That drainage is absolutely essential.
(3) That double applications of bituminous material have proven more successful than the single, except when treating old bituminous and concrete pavements.
(4) That a "mat coat" properly constructed on a firm base generally is a good financial investment.
(5) That maintenance on this type of road in Florida is not any greater than on the higher types of pavement.
(6) That the price of "mat" or "carpet coat" construction varies from 19 to 25 cents per square yard exclusive of the base.
(7) That a good "mat" or "carpet coat" will carry traffic up to 2,000 vehicles per day economically.
(8) That bituminous "mat coats" can be used on old slick pavements to obtain a non-skid surface.
(9) That slag is proven to be the most satisfactory cover material, followed secondly by crushed stone and crushed gravel.
(10) That laboratory control and field tests are essential in obtaining the best results.
(11) That bituminous materials used in "mat" or "carpet coat" construction, and also "mixed-in-place" construction is a life-saver in the problem of low cost roads.

CHAIRMAN HUBBARD: I think Mr. Weathers should be congratulated on presenting this able paper on that practice as well as on the very good illustrations he has presented. I might say that the best "mat" treatments that it has been my pleasure to see were in the State of Florida, and were constructed in accordance with the methods which have been described by Mr. Weathers. Since there is no further discussion, we will proceed with the next paper on the program, dealing with "The Use of Asphaltic Materials in the Cold Premix Types," and scheduled for presentation by Mr. C. A. Mullen of the paving department of the Milton Hersey Company at Montreal, Canada. Unfortunately Mr. Mullen cannot be with us since he has been kept at home by the illness of his daughter. His paper will be read by title and published in the proceedings.

# The Use of Asphaltic Materials in the Cold Premix Types

**By C. A. Mullen, Montreal, Quebec, Can.**
*Consulting Paving Engineer, The Milton Hersey Company, Ltd.*

If this report deals more with generalities and less with details than it should, and if the work discussed is confined to my own experience, I trust the conference will understand that this is done as a matter of necessity and not as one of choice. Montreal is up in the northeast corner of the populated area of this continent and visiting the work of our neighbors is not as easily managed as in the case of an engineer located somewhere around, let us say, Memphis, Tenn.

As far as I know, the first cold-laid, premixed pavement ever laid in Canada was the old "Von Westrumite," the asphalt cement for which entered the mixture cold and in the form of an emulsion with water, the aggregate also being cold and undried. After a period of years, laying of this pavement was abandoned but some of the streets paved with it, up to a few years ago, were rendering service on residential thoroughfares. I do not know of any of it that remained in place very long under heavy traffic. The basic "Von Westrumite" patent expired some years ago.

Then came "Amiesite," with a cold aggregate, primed with a volatile oil and coated with asphalt, with a small percentage of hydrated lime added to assist in the distribution of and to stiffen the asphalt. "Macurban" is produced somewhat like "Amiesite" but the grading of the aggregate and the method of construction are different and no hydrated lime need be used. Since the expiration of the basic "Amies" patent many similar pavements have been laid in several sections of the United States. Some have been laid in Canada.

### COLD PREMIXED TYPES IN CANADA.

Today, two new pavements of the cold, premixed type are offered in Canada. These are "Macasphalt" and "Colprovia." Another is about to make its debut but it has not yet been christened. Also, the method of premixing aggregate with emulsified asphalt, a la Von Westrum, is to be tried out in supposedly improved form next season and, all in all, we expect to have an interesting time of it in that good country to the north of us, which is said to be bounded on the south by the U. S. A., on the north by weather, and where I have lived for some years past.

"Macasphalt" and "Macurban" have been combined in what the engineers of the Quebec Provincial Road Department seem to think a satisfactory provincial highway pavement, the bottom being a "Macurban" asphaltic concrete and the top a wearing surface of "Macasphalt." A highway leading to the mountains north of Montreal, paved several years ago with "Macurban", four inches thick on an old gravel bottom and still in prime condition, is planned gradually to be stage-constructed into a thicker pavement by the addition of a "Macasphalt" top, as section upon section may seem to need this additional protection and strengthening.

The "Macasphalt" method lends itself to the production of a peculiar non-skid surface of the sandpaper variety, and on the mountain highway to which I have just referred, where the present "Macurban" roadway has one of the best non-skid surfaces I have ever seen of the stone-rough type, the "Macasphalt" surface is providing a smoother textured surface that possesses a different kind of roughness and that is in strong comparison as to type. That both surfaces possess excellent non-skid characteristics is obvious to one using this road but which of the types ultimately will prove preferable I today am not prepared to say.

The "Colprovia" so far laid in Canada has met with considerable approval. There are plants in both Quebec and Ontario and work for them is being secured. The "Colprovia" method, as was well described at the last conference by Mr. Dow and others, is the priming or coating of cold stone with cold flux-oil which will mix with it at atmospheric temperatures and secure distribution throughout the mass of the proper amount of hard powdered asphalt. These materials flux cold and in that way they make an asphalt cement after the pavement is laid. In "Macasphalt", the flux oil and powdered asphalt are made into a cement and this cement is applied to the aggregate. The bituminous materials used, however, are not the same.

### Emulsions and Cut-Backs Being Introduced.

The new emulsion premixes have not made much headway in Canada. I have had no opportunity to observe any of this work. It seems to me to present several difficulties not encountered with the other premixed asphalt paving compositions but one can never tell just how far an old method which has not been a great success will go in the hands of highly interested and more youthful technicians. Each decade in the paving art makes possible methods that to a previous decade seemed impossible, since year by year the improvement of equipment and the refinement of detail goes forward apace. Neither has the use of cut-back asphalt, premixed, been very far developed in our section, though some have been employed successfully.

This report, as I think was understood from my early remarks, is more of a preliminary statement than a study of the subject such as I think should be presented before this conference. What we, as an industry, require to know is just what is being done in all parts of the country, so that methods and materials may be more or less classified, costs compared in a general way and qualities studied in relation to costs and convenience of use. The latter is really an item of cost.

During the present winter the party who is to report under this heading at the next conference should initiate and carry to a satisfactory conclusion a correspondence with all those engineers and producers who are ready to cooperate. I believe most of the engineers and producers will cooperate. Most of us, today, are becoming "industry conscious," and we are anxious for the general progress as well as for our own individual profit and progress. For the man who unreasonably refuses to cooperate we shall have to invent some form of industrial ostracization.

Looking at our problem in a broad way, do not most of us need to be reminded that, after all, premixes for cold laying first must be compared as to quality and cost with the present well developed art of premixing for hot-laying? At the prices for which good work by the old method now is being done in many parts of the country, the competition for general use is going to be pretty steep for the cold-laid mixtures in locations within hailing distance of a regular old line asphalt paving plant. However, cold-laid mixtures have their special field and special advantages in any field.

### Field for the Cold-Laid Mixtures.

Beyond the practical transportation limits of the hot mix, in relatively small areas on village streets and country highways, there is a considerable field which may be said to be the cold-laid mixture's own. One cannot afford to go to the expense of moving an asphalt plant to a locality for a small yardage, or to keep it there even to do a large yardage at disadvantageous time intervals. It is much cheaper to ship the cold-laid mixture, even at what seems a high price per ton. This field, we may say, is the legitimate unquestioned field of the cold-laid mixtures. But there is another field into which it will undoubtedly break.

There is no particular reason why cold-laid premixes may not break into direct competition with the hot-laid premixes on any work whatever if they can produce the same results at the same cost, everything considered. Today, when the cold-laid premixes still are loaded down with heavy development costs, royalties and so forth, they are at a handicap in this field. But as time goes on and the unavoidable costs of this nature gradually are liquidated such direct competition will be possible. In fact, there are those who are proving that it is already possible by their actions in certain fields.

There is much to be written yet as to the relative merits of the two methods,—hot-laid and cold-laid. The honors are by no means all on the side of the hot-laid method. Cold-laid for instance, gives all the time in the world for careful workmanship in the construction. And compaction after laying goes on more satisfactorily and more rapidly with this type. Also, when the thermometer stands at 100 in the shade the life of a workman engaged in spreading and finishing such mixtures is more liable. These are only two of the items which occur to one at once but there are many others to be entered in our record.

In Canada, very little rock asphalt has been used in highway surfacing. I know of only one short section of sandstone cold-laid pavement, and none of limestone rock. In the West, the Alberta asphaltic sands have been used locally but this material has not been subject yet to very extensive commercial development and probably will not be for years to come, except for the extraction of the heavy asphaltic oil. The reason for this is the sparsity of population within economic freight distances, for the material itself, if cleverly handled, would make a very good roadway mixture for cold laying.

### ASPHALT COLD MIXTURES SUPERIOR TO TAR.

My impression, though I have made no very careful inquiry, is that many years ago the English engineers were making premix for cold-laying. The bitumen mostly was tar but they had some success with that. If one is to judge by the recent reception in England of premixes of the "Amiesite" and "Colprovia" types, in which asphalt is used, the tar premix left much to be desired, despite the fact that, if general information is correct, the English tar is better than usually is available on this side of the ocean.

Activity in the premix for the cold-laid field is in evidence all over the country. Many engineers report a satisfactory use of the patented types in this field, but others are using such mixtures designed in accordance with the publicly-owned prior art. Mr. A. K. Vickery, city engineer of Denver, for instance, reports laying a cold-laid premix at 40 cents per square yard, though at this time I have no information as to the type. The City of Washington seems to have its own cold-laid premix and undoubtedly there is a lot of other experimentation going on which should be included in this annual report as soon as information concerning it can be collected and correlated.

On the other hand, the producers of proprietary premixes for cold-laying of course are steadily improving their products and, in the face of the competition of one such premix with another, prices are seeking an economic level not based on a monopoly in their class by any one of these proprietary products. Some engineers report large programs satisfactorily carried through with one or the other of the trade-marked or patented mixes. There seems still a good field in this branch of the industry for invention and patent protection on same and that without necessitating the sale of patented products at extortionate prices.

CHAIRMAN HUBBARD: The next paper is "The Use of Asphaltic Materials for Joint Fillers and Crack Fillers," by Mr. Clarence D. Pollock, consulting engineer of New York City. I take pleasure in introducing Mr. Pollock.

# The Use of Asphaltic Materials for Joint Fillers and Crack Fillers

**By Clarence D. Pollock**
*Consulting Engineer, New York, N. Y.*

We were disappointed in the results obtained from the questionnaires on this subject and had hoped that we would get more help touching upon this subject. This paper is made up largely from my personal experience and my observation of the experience of others. I am in hopes that it may start further examination into fillers. We should see if we cannot develop something better than that which we have today.

In laying a unit type of pavement the question of the joint filler is an important factor which should be carefully considered. As in everything else, there is no "cure-all." Under some conditions one filler seems to give the best results, and under other conditions some other filler has been more satisfactory. This subject is deserving of more study than has been given it in the past. In the earlier stone block pavements, the blocks were laid without a foundation. They were simply paved upon a sand bed or cushion and the joints were filled with sand. A covering of sand was left on the surface of the pavement usually for about a month, or until the blocks were firm and the joints would take no more sand.

## THE OLD TAR AND GRAVEL FILLER.

When foundations came into use a better joint filler was sought and the so-called tar and gravel filler came into use. This usually consisted at first of coal tar pitch, which was heated and poured into the joints after they had been partially filled with washed gravel. Then more hot gravel was added and the joints again were poured until they remained full. As early as 1895 this filler was improved by the addition of asphalt, which made it less susceptible to temperature changes. With the advent of smaller and better cut blocks the gravel was omitted, as the joints were too narrow to permit it to penetrate them. A mixture of asphalt and sand then was developed and this has proven very satisfactory when properly applied. Other fillers on the latter principle have been made on a commercial scale, with the mineral matter incorporated before delivery.

In the course of the development in fillers a cement grout, made of equal parts (by volume) of Portland cement and sand, was used in the case of both stone block and brick pavements for some time. This made a very rigid pavement and expansion troubles often developed, especially in the case of brick pavements. Expansion joints then were inserted and from this, by evolution, came the asphalt and asphalt mastic fillers where every joint affords relief for expansion and contraction.

The requisites of a good filler are: (1) that it should hold the blocks firmly in position; (2) remain permanently in place, and (3) afford support to the edges of the blocks, thus preventing chipping and a consequent rounding of the heads of the blocks. The filler should be easy to apply and reasonable in cost. It should be a material that will permit the pavement to be opened to traffic directly after it has been placed in the joints.

### Application of Filler with Tanks.

Asphalt mastics, of all the materials in use at the present time, when properly made and properly applied, seem best to satisfy the above requirements. However, in the case of brick pavements, when the bricks do not have lugs to space the courses, it has been found difficult to obtain a thorough penetration of the mastic into all the joints and, consequently, a straight asphalt filler generally has been used. This sometimes has resulted in more or less trouble during warm weather, as the filler softens, swells out upon the surface of the pavement and becomes "mussy" under traffic. When lug brick are used or spacers are employed to separate the bricks, an asphalt and sand mastic has been used with very satisfactory results. A good example is the result accomplished in New Orleans by City Engineer Bryson Vallas. He has used an asphalt mastic in the joints of his brick pavements which has penetrated the joints completely and has remained there without bleeding under traffic, notwithstanding the warm climate of that city.

Formerly the filler in brick pavements was applied by means of a conical can having a needle valve in the bottom. This was carried along the joint by hand. Generally most of the filler was placed in the joints and relatively little was placed on the surface. However, it was costly in labor. Later the filler was applied in larger volume to the surface of the pavement from a tank on wheels, the flow being regulated by means of a needle value in the bottom of the tank. Immediately behind the outlet of the tank was placed a curved squeegee having a piece of belting on the bottom edge. This worked quite satisfactorily, although at times there was trouble because the asphalt tended to "gum up" on the squeegee. This trouble, however, was not serious if the work proceeded without interruption or delay. On the whole, hand squeegees having steel blades which are kept hot are the most effective in avoiding a surplus of asphalt on the surface of the brick pavement. In using them the filler may be flushed over the surface.

### Tools Should Always be Hot.

The most widely used mastic for stone block fillers is one in which the asphalt has a penetration of 60 to 70, at 77 degrees Fahrenheit, which is the third filler in the list of four in the pamphlet issued by the Division of Simplified Practice of the U. S. Department of Commerce. To this is added dry, hot sand, all of which will pass a ten-mesh sieve, with not less than 85 per cent passing a twenty-mesh sieve. The best results are obtained when, as nearly as possible, 50 per cent of the mixture, by volume, is sand. The more sand that the mixture will carry and still flow into the joints readily, the better the resulting filler. This is about the maximum amount of sand that the asphalt will carry and still flow properly.

This filler has proven satisfactory, in most cases, when heated to the right temperature and kept there until flushed over the surface of the pavement. In the spreading of the mastic into the joints it is very important to have the tools properly heated and changed for freshly heated tools with sufficient frequency. Unless the tools are kept hot it will be impossible to get all the asphalt off the surface of the pavement. It is very essential that no more of the mastic be left on the surface than can be helped. Some engineers are even going back to the pouring method in order to keep the mixture off the pavement surface. However, in the case of stone block pavements, when reasonable diligence is used in flushing the hot mastic over the surface and shoving it off the surface with hot tools, the small amount that cannot be removed from the pavement surface does no harm. In fact it is of some benefit in cushioning the low spots in the heads of the blocks until the traffic wears down the high points in the heads, thus producing a smoother surface, in time, than when the pavement first is laid. Such a light film readily will be worn off by traffic and will cause no inconvenience.

### FLUSHING METHOD REDUCES LABOR COST.

In some cases, with intensive and heavy traffic, the above mastic has softened and come out on the surface in very warm weather but investigation has shown that this was due in large measure to the fact that insufficient sand was used in the mastic. In the worst case the records showed that only 30 per cent of sand was used instead of the 45 to 50 per cent which should have gone into the mixture. In addition, a large amount of the mastic was left on the surface because of carelessness in using cold tools and also in not providing the proper means of maintaining the heat in the sand until after its incorporation into the mastic. Under similar traffic conditions an asphalt having a penetration of 50 to 60 at 77 degrees Fahrenheit now is being tried and, when mixed with about 50 per cent of hot sand it seems to flow into the joints about as readily as that having a penetration of 60 to 70. Either of these asphalts should give good results if properly handled and used. There seems to be more need for improvement in workmanship or manipulation of the work than in the materials now in use.

While the method of flushing the mastic over the surface of the pavement and pushing it into the joints with hot squeegees uses more material than the old hand pouring method, it reduces the labor cost considerably. In the earlier days the pouring was done with buckets or cans having a short spout, but in windy weather much of the material was blown over the surface of the blocks and it required good inspection to get the joints well filled, as the laborers had a tendency to hurry along in order to cover the ground and not to wait for the filler to flow down into the joints. The wheeled tanks have overcome this condition to a great extent.

After the joints are filled thoroughly and the surplus mastic has been squeegeed off the surface of the blocks, a thin layer of sand or stone dust is spread over the surface to prevent traffic from sticking or picking up the film and to aid in grinding off the coating.

As was mentioned before, premixtures of asphalt and slate dust, limestone dust, etc., have been made commercially. But these have been developed mainly for joint and crack fillers in concrete pavements, although they have been used to some extent in stone block pavements, especially by New Jersey and Pennsylvania, which states have also used them in construction joints for concrete pavements. For more than two years past the New Jersey State Highway Department has used a prepared mastic filler in granite block pavements and in construction joints in concrete pavements under the designation of B. M. 2., which is composed of asphalt having a penetration of 85 to 100 at 77 degrees Fahrenheit and with about 45 per cent, by weight, of slate dust. The New Jersey engineers consider that they have obtained better results with this preparation than with the asphalt and sand mastic.

The Pennsylvania Highway Department has used a prepared filler, almost identical with the above B. M. 2., which the department calls Specification J., No. 1. Other fillers which are made commercially are used to a considerable extent and these usually contain various forms of mineral matter. For a crack filler the New Jersey State Highway Department is using a filler designated as B. M. 3., in which the asphalt has a penetration of 85 to 100 and contains 20 per cent by weight of slate dust.

Crack fillers have conditions to meet that are quite different from those affecting joint fillers. The cracks generally are small and it is necessary to use asphalts having higher penetrations than those used for the joint fillers, or to use less mineral matter, if a mastic be desired. From about 75 per cent of the state highway departments which answered our questionnaires it was reported that a filler was used in which the asphalt had a penetration of 85 to 100 at 77 degrees Fahrenheit. About half of these called for a filler containing mineral matter. The balance of the state engineers and the county engineers reported using asphalts having penetrations of 50 to 60. Various machines have been used to some extent for pouring both joints and cracks.

## The A. S. M. I. Filler Specifications.

Various specifications have been followed for joint fillers, but the one most generally adopted for the asphalt in the mastic used for the stone-block-pavement filler, is that of the American Society for Municipal Improvements, which is as follows:—

> Asphalt Cement Filler. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:
>
> (a) Penetration at 25 degrees C. (77 degrees F.) 100 g., 5 sec.—60-70.
>
> (b) Flash point (open cup)—not less than 175 degrees C. (345 degrees F.)
>
> (c) Loss on heating at 163 degree C. (325 degrees F.) 50 g., 5 hours........not more than 2 per cent.
> Penetration at 25 degrees C. (77 degrees F.), 100 g. 5 sec., of residue after heating at 163 degrees C. (325 degrees F.) as compared with penetration of asphalt cement before heating........not less than 60 per cent.
>
> (d) Ductility at 25 degrees C. (77 degrees F.)—not less than 30 cm.
>
> (e) Proportion of bitumen soluble in carbon tetrachloride ........not less than 99 per cent.

The object to be attained with a crack filler is to have it flow freely into the cracks and adhere to the sides, to have it stable and to prevent the entrance of moisture. On the other hand a joint filler must flow into the joints readily and must harden sufficiently to protect the edges of the blocks or the pavement against chipping. In joint fillers for stone block pavements, the tendency today is towards as hard an asphalt as will flow into the joints properly when made into a mastic containing the optimum of mineral matter content; viz,—as near 50 per cent by volume of sand as will flow readily. The object is to make the joint resemble, as nearly as possible, a little section of rich asphalt pavement between the blocks.

It is suggested that more study be given to this subject, both in regard to materials as well as to their manipulation. It may be possible to develop a cut-back asphalt mastic or grout filler in which the shrinkage would be small and which would thereby eliminate the troubles that sometimes result from improper heating on the street.

## DISCUSSION.

CHAIRMAN HUBBARD: Gentlemen, Mr. Pollock's paper is now open for discussion. I think Mr. Pollock has developed quite thoroughly the fact that in many cases when unsatisfactory results have been obtained the fault lies largely in lack of attention to construction details, which are recognized by the engineer but are not insisted upon by him in the contractor's operations. The asphalt industry, I know, stands ready to improve the character of filler for brick and block pavements wherever and whenever it can but I do not believe, and I think you will agree with me, that any modification of existing material will serve as a remedy for faulty methods of application which are now too commonly followed. I would like to hear from engineers who are interested in this phase of the subject.

MR. H. L. HOWE, Rochester, N. Y.: I would like to ask Mr. Pollock whether that specification which he did not read because of detail, covers the blown type of asphalt filler that we use so much in the cities,—that is, to say, an asphalt cement or filler with a high melting point?

MR. POLLOCK: As I remember, when that specification was adopted, we tried to make it cover all the fillers that we could find. I think it does. Probably Mr. Hubbard can answer that better than I can. I do not have the details of the analysis in mind.

CHAIRMAN HUBBARD: The specification about which you are inquiring, Mr. Howe, is the specification of the stone and block filler and is an unblown product,—that is, it is a regular grade of paving asphalt cement. Any further discussion?

MR. POLLOCK: If Mr. Vallas is here I think he can give us some interesting experiences with plastic filler in New Orleans. As I remember it, he did not use as much as we use.

CHAIRMAN HUBBARD: Is Mr. Vallas in the room? Is there any one from New Orleans who can tell us that? I guess not, Mr. Pollock. Is there any further discussion?

If not, we come now to the opening of the last session of this conference, which is conducted by the Association of Asphalt Paving Technologists. It has been customary to hold this session immediately preceding the annual business meeting of the association and to have the retiring president preside. The annual business meeting, however, was advanced to last night and at that meeting a new president was elected. I have the pleasure of announcing that our president for the next year is Mr. Charles A. Mullen of Montreal. Since Mr. Mullen is unable to be with us today and cannot, therefore, preside, I am going to ask First Vice-President Henry R. Howe to take the chair.

VICE-PRESIDENT HOWE: The first paper on the program of the joint session of the Ninth Annual Asphalt Paving Conference and the annual meeting of the Association of Asphalt Paving Technologists is entitled "The Use of Asphalt Surfacing on Old Gravel Roads." It will be presented by Mr. C. R. Stokes, materials engineer of the Wisconsin State Highway Commission, Madison, Wis. Gentlemen, Mr. Stokes.

# The Use of Asphalt Surfacing on Old Gravel Roads

### By C. R. Stokes, Madison, Wis.

*Materials Engineer, Wisconsin State Highway Commission*

During the past few years there has been an increasing tendency on the part of several states, toward attempting to preserve low-type surfaced roads or existing bases by providing bituminous wearing surfaces thereon. Some states apparently have been quite successful and, through their efforts, have obtained satisfactory wearing surfaces presumably at low cost. However, it seems, at least to the author of this paper, that such work is still in the experimental or research stage, proven by the fact that so many different types have been tried and that some unquestionably have been found inadequate. Yet the question of preserving low type surfaced roads and existing bases seems to be a problem well worth studying. The successes or failures to date are hardly sufficient to supply the answer.

Wisconsin has a rather large mileage of gravel and stone surfaced highways. Many of these are in splendid condition and it is likely that a large portion of them would provide excellent bases for preservation. A few have already been selected for purposes of experimentation and various types of resurfacing have been tried. This paper can hardly cover the various types but can describe a section of highway, built during the 1930 season, which presents some rather interesting features.

U. S. Highway No. 2 in Florence County, located in the extreme northeastern part of Wisconsin, was selected for the work. This highway traverses the county for a distance of 14.05 miles and crosses the Michigan state line at either extreme of this distance. It carries an average of about 840 motor vehicles per day. The entire distance of 14.05 miles, with the exception of a half-mile previously paved in the village of Florence, was included in the project. The existing road was gravel surfaced throughout and provided an excellent base for resurfacing. The soil adjacent to and under the road, in general, was a light, sandy loam which provided good drainage. There was one stretch of about 2,000 feet where the road traversed fairly heavy clay soil and where at certain times of the year there was some frost boil action. However, it was by no means an extremely serious condition.

"Retread" Work, Wisconsin State Highway Department. Bituminous Treated or "Mixed-in-Place" Asphalt Surface on Old Gravel Base. Power Graders in Pairs Turning and Mixing.

It was decided that the project should be split into two sections and two types of bituminous surfacing, each having a full depth of three inches and an overall width of 20 feet, should be built. Each type was to have a thickened edge approximately of five inches extending in from the outer edge one foot. One section, 6.15 miles in length, was a two-inch compacted "retread" base and a one-inch top of cold premixed bituminous material. The other section, 7.4 miles in length, virtually was a one-inch asphaltic concrete top on a two-inch asphaltic binder course. Bids were taken on the project with the exception of the work of blading and shaping the old gravel road and constructing the shoulders, this being done by county force account. Each section was let to two different contractors with separate outfits. The project was ably supervised by a resident engineer of the highway department and a commercial testing laboratory. The state highway laboratory assisted in the acceptance tests of materials. The commercial testing laboratory furnished experienced inspectors to supervise the actual work on both sections of the project as well as a field chemist for the plant control. The author wishes to take this opportunity to commend the organization perfected by the commercial laboratory for its fine work and cooperation.

The actual designs of the mixtures, materials used, etc., were pretty well covered by the specifications, although some changes were necessary. The primer coat for the whole road was a light cut-back asphalt. Commercial crushed limestone and traprock having a French coefficient of approximately 10 were used in the "retread" base course and the bituminous applications were of heavy cut-back asphalt. The premixed cold bituminous top consisted of 80 to 90 per cent of stone, graded from five-eighths of an inch down, 5 to 7 per cent of bitumen and a small percentage of liquifier and filler.

The mixtures for the asphaltic concrete sections were designed to the maximum of stability, workability and compressibility. Each 1,000 pounds of binder contained 40 to 43 pounds of asphalt cement, 200 pounds of sand and approximately 760 pounds of stone. Each 1,250 pounds of asphaltic concrete top consisted of from 68 to 70 pounds of asphaltic cement, 494 pounds of sand, 536 pounds of stone and 150 pounds of filler. The asphalt cement was a Mexican paving asphalt of 70 to 80 penetration. The stone and sand for these mixtures were furnished from the contractor's local screening and washing plant which was operated locally near the project. They were obtained from a gravel pit where the general run of the material was of a hard, igneous type. Some fine sand was obtained from a bank near the asphalt plant set-up. The stone for the binder course was graded well up to one and one-half inches and that for the top up to five-eighths of an inch.

### DENSITIES OF THE MIXTURES.

The mixtures for the hot-mix section seemed to bear out the advantage carefully of designing and controlling such mixtures. They were remarkably uniform from day to day and were very easily handled and compressed. Densities of mixtures were computed from laboratory samples and field samples of the rolled mix and they showed an average of 2.40 for the top and 2.42 for the binder. The stability of the top mix ranged

"RETREAD" WORK, WISCONSIN STATE HIGHWAY DEPARTMENT. BITUMINOUS "RETREAD" OR "MIXED-IN-PLACE" READY FOR ROLLING.

from 42.5 to 45.8 pounds per square inch in shear. The use of such a soft asphalt cement somewhat is out of the ordinary but it is entirely in line with the best practice, which should contemplate using as soft an asphalt cement as possible without sacrificing too much stability. The mix is more durable when a softer asphalt is used and is less apt to crack. At the same time the shear results secured for the mixtures on this project should be sufficient to insure ample stability. The actual bitumen content was determined from the voids in the aggregate and it was kept just below the amount required completely to fill all voids.

The work of preparing the road on the two sections practically was the same throughout. The gravel surfaced roadway first was bladed and then a small V-shaped trench was cut along the outer edges to take care of the thickened edge design previously mentioned. The subgrade thus established was then prime-coated with the light cut-back asphalt at the rate of one-half to three-fourths of a gallon per square yard. The amount specified was three-fourths of a gallon but that actually used was dependent on how much the gravel would take up. This varied with respect to the quantity of clay present in the gravel and also as to the amount of oil still remaining, since the road had received an application of light road oil the previous year. Small areas of loose gravel or sandy subgrade were removed and filled later with the base course composition. Whereas a complete detour was established for the project, traffic was allowed over the road within three days to a week after the prime coating.

### CONSTRUCTION DETAILS—COLD-MIX TYPE.

As soon as feasible after the prime coat had been applied both contractors started the work of placing the surfacing on their respective sections. As the methods of construction essentially were different they will be taken up separately. The first operation on the "retread" section consisted of hauling and spreading the crushed stone. The stone was delivered in railroad cars at a siding about midway in the section and loaded into trucks directly through batch-bins. It was hauled to the roadway and spread upon the subgrade in sufficient quantity to produce a two and one-half inch loose depth over all, allowing for the extra material required to fill the side trenches. The stone was graded from three-quarters of an inch to one and one-half inches in size, and the amount necessary for the twenty-foot width was about 1,000 cubic yards to the mile. After this stone was spread and bladed, all stone in the side trenches was removed and thrown into the roadway proper before applying the bitumen. The heavy cut-back asphalt was applied by a pressure distributor at about 175 degrees F. in two separate applications of about equal portions with a total amount of three-quarters of a gallon per square yard. After the first application the blading was started at once and was continued until all stone had become partially coated and the mixture had attained a uniform color.

The blading was from side to side and usually about eight separate bladings were necessary. Two and sometimes three power blades were used in this work. On a few occasions the stone, with its first application of bitumen, after mixing, was bladed into windrows and allowed to stand over night, when it again was spread out by blades before applying the second increment. Such procedure, however, might be inadvisable under adverse weather conditions. Immediately following the final blading, after the first application of bitumen, the second coating was applied and the same process of blading was repeated. At this time the mixture was bladed into the side trenches. The last blading operation produced the final grade. During the blading operations it sometimes was necessary to resort to hand work to keep the side trenches free of stone. After the last blading the base was rolled with two three-wheeled ten-ton rollers until unyielding. Any low places which were present after rolling were filled in with material and rolled.

Premixed Top Course on Old Gravel Base. Wisconsin State Highway Department. Note the Non-skid Surface.

### Final Compaction and Traffic Action.

After the base course had been rolled thoroughly the keystone was applied by means of a spreader box attached to the trucks. This stone was a gravel aggregate graded from three-eighths to five-eighths of an inch and was applied at the rate of about fifteen pounds per square yard. It was distributed by brooming or float-dragging and then was rolled thoroughly into the base. The base course was opened to traffic as soon as possible after the final rolling. The traffic helped to compact the base. In fact it seemed to have a better tightening action than the roller. There were no break-ups at any point in the base.

After about ten days of traffic on the base the contractor started laying the premixed cold bituminous top. This material was manufactured at a rather distant point in the state and was shipped to a siding near the job in railroad cars. Cars were steamed with 80 to 90 pounds of pressure, which resulted in heating the mixture to about 125 degrees F. This was done to facilitate unloading. The material was unloaded directly into trucks by means of a clam-shell bucket. The mixture was shovelled and raked into place by hand and rolled with a three-wheeled ten-ton roller as soon as raked. Washed sand, at the rate of about six pounds to the square yard, then was cast upon the surface to prevent "picking up" under traffic. It was opened to traffic immediately and, after one or two weeks, a seal coat of heavy cut-back asphalt was applied at the rate of about one-fifth of a gallon per square yard. Sand then again was cast over the whole surface. This completed the work on this section and the surface was finished except for the final compression which occurs under traffic.

Asphaltic Concrete Construction Over Old Gravel Base. Wisconsin State Highway Department.

The mixtures for the asphaltic concrete section were produced at a railroad-car plant with a rated capacity of 2,000 square yards of two-inch surface per day. The plant was equipped with screens and storage bins for three sizes of stone and one of sand. Each ingredient was weighed accurately into a batch-box which discharged directly into the pug-mill mixer. Aggregates were delivered to storage piles at the plant by truck and handled to the material elevators by crane. Asphalt was supplied in tank cars and was pumped from them directly to the plant, via a single storage tank. In the mixing operation aggregates were drawn into the mixer first and were given a dry mix of thirty seconds for the top and fifteen to twenty seconds for the binder. Then the asphalt cement was added and the whole was mixed for another fifteen to twenty seconds. It is believed that this procedure insures against thin films of asphalt cement in contact with mineral at 450 to 600 degrees F., as so often is the case when the asphalt cement is drawn together with or immediately after the mineral and no dry mix is given to bring dust and sandstone to a common temperature of about 40 degrees F.

### FINISHING MACHINE IS USED.

The policy throughout this section was to lay binder in the afternoon and cover it with top the next morning. A small portion of the work was laid by the usual hand method of shovelling the hot mixture into place and raking to grade. The other portion was laid by means of a finishing machine designed to handle asphaltic mixtures. This machine rode on secured steel side-forms, set to grade. The front screed member was adjusted vertically so that it dropped down inside the forms when the binder was being laid and rode the forms when the top was being laid. By virtue of this riding on top of the forms the entire weight of the front screed mechanism rested upon the freshly placed top mix and the result was that very little so-called "knockdown" remained for the rollers. In other words, the screed applied an initial compression of considerable consequence.

The binder mixture was delivered by truck to the roadway, deposited on the subgrade and shovelled roughly into place. It was raked out by hand or struck off by the finshing machine. It was rolled immediately by means of a three-wheeled ten-ton roller and a ten-ton tandem roller. On a part of the job the side trenches were filled in advance of the regular binder course and were tamped in place by hand. This proved to be the best procedure on the all-hand work but in the case of the machine-finished work the trenches were filled along with the spreading of the entire width. There were some loose sections of subgrade, especially at each location of the truck turntable and at these points the loose material was removed and replaced with binder, which was rolled thoroughly. In fact all unevenness in the subgrade was corrected with binder mixture.

MECHANICAL SCREEDING AND FINISHING OF ASPHALTIC CONCRETE OVER OLD GRAVEL BASE. WISCONSIN STATE HIGHWAY DEPARTMENT.

On all the machine work the forms were required to be in place until after the top was laid, being removed immediately following the final rolling. On all hand work they were removed the following morning after the binder was laid and were not used for the top. Instead, wooden strips of the proper thickness were spiked along the outer edge of the binder laid the previous day. The top was laid in the same manner as the binder. The top mixture was delivered to the work at a temperature of about 325 degrees F., while the binder approximated 275 degrees F.

### LABOR AND QUANTITY OF MATERIALS USED.

Both binder and top, as well as the "retread" section, carefully were straight-edged and any unevenness of surface immediately was corrected. Following the final rolling of the top, Portland cement was swept into the surface and rolled.

Some facts about both portions which are rather interesting are as follows:

*Retread Section.*

(1) Prime-coat work required a distributor and three men.
(2) Spreading stone required three trucks, one crane and three to five men.
(3) Applying bitumen and general work on "retread" base course required a distributor, three trucks, two bladers, two rollers and nine men.
(4) Premixed top required trucks, rollers and a crew of sixteen men.
(5) Stone was spread at rate of about 260 cubic yards per working day.
(6) Average premixed top laid per day, 1,975 square yards.
(7) Total cut-back asphalt used for prime coating, 48,888 gallons.
(8) Total cut-back asphalt used in base course, 60,330 gallons.
(9) Total cut-back asphalt used in seal coat, 12,023 gallons.
(10) Total crushed stone used for base course, 6,100 cubic yards.
(11) Total premixed top mixture used, 7,434,000 pounds.

*Asphaltic Concrete Section.*

(1) Prime-coat work required a distributor and three men.
(2) Plant crew consisted of one foreman, two engineers, eleven laborers and five trucks and drivers.
(3) Roadway crew included one foreman and nine laborers on forms and turn-table, one foreman, two roller men and eleven laborers on the laying operation.
(4) Average production per ten-hour day of completed three-inch pavement, 1600 square yards.
(5) Total cut-back asphalt used for prime coating, 45,614 gallons.
(6) Total binder mixture, 12,750 tons.
(7) Total top mixture, 4,973 tons.

Ideal weather conditions prevailed throughout the work. There was very little rain and the weather was hot, the temperature averaging about 78 degrees F.

As far as the cost of this type of improvement is concerned, the figures available are based on the actual contract prices. The force account agreement with the county for preparing the subgrade and for reshouldering amounted to $1,100 per mile. The cold-mix section involved 72,830 square yards and the total cost per square yard was $.96. The hot-mix section involved 87,417.7 square yards and the total cost per square yard was $.93. The total engineering cost on the whole project, including plans, inspection, supervision, tests, etc., amounted to $8,721. The cost per mile of the whole project, including the county force account, but not the engineering costs, amounted to $12,250. If the engineering costs are included the cost per mile would be $12,891.

### CONCLUSIONS AND RECOMMENDATIONS.

Experience in the construction of these two sections suggests to mind a few improvements and details which might be advantageous in work of this nature. First of all it is believed that there might be considerable advantage in prime-coating work of this type considerably in advance of the actual construction. This would give traffic an opportunity to stabilize the subgrade and develop any loose or weak spots which could easily be corrected during the work. The presence of fresh prime-coat material is not particularly objectionable on cold-mix work but it is on the hot mix unless it has completed its evaporation. At the start of the asphaltic concrete section, a few small spots of freshly applied prime coat bled through the binder and top. These spots had to be cut out and replaced. Secondly, in binding the prime coat for immediate traffic, pea gravel or small stone chips should be used instead of throwing on the sandy and dusty material from the shoulders. This latter material tends to seal into a mat and prevent evaporation, which is essential in the use of cut-back asphalt.

COMPLETED ASPHALTIC CONCRETE SURFACE ON OLD GRAVEL BASE. WISCONSIN STATE HIGHWAY DEPARTMENT. NOTE THE WIDE, NON-SKID SURFACE BLENDING WITH THE SHOULDERS.

The use of the V-shaped trench to produce the thickened edge is objectionable from the standpoint of construction. On the "retread" section it practically was impossible to secure as smooth a surface in the outside foot or so as in the main portion of the pavement, due to uneven compression in the trenches. On the hot-mix type, laid by machine, the trench section was more easily handled. It is possible that a widened base might be more desirable as an edge protector. Undoubtedly one of the most interesting features of the work was the use of the finishing machine. A most excellent grade was left by the machine on both binder and top. Its use has been reflected in the riding quality on the section in which it was used, for there are fewer inequalities and less unevenness in this portion than in the rest of the work. An item of equipment which undoubtedly would have assisted appreciably in the work, would have been the employment of spreader boxes on the trucks dumping hot-mix material. Two or three men could have been eliminated had these boxes been used. However, in general, the two sections constructed in Florence County are satisfactory and, being two distinctly different types, it will be very interesting to observe their appearance after a few years of service.

## DISCUSSION.

CHAIRMAN HOWE: I think Mr. Stokes has given us a very interesting and comprehensive paper dealing with this problem. I am sure it will call for some discussion and probably some questions. If there are any questions let us have the questions first and the discussion afterwards. I might, myself, ask one question of the author of the paper and that is, are these two sections going to get about the same amount of traffic, so you can get at the comparative value of the different methods?

MR. STOKES: I don't know whether I made myself plain on that point. This really was one project of about fourteen miles in length. We merely divided it into two sections, one immediately adjacent to the other on the same highway and we let the work to the two contractors with the idea that we would lay the two different types of work. We let the cold-mix section to one contractor and the hot-mix section to the other. The road does not get a great amount of through traffic, with the exception of the traffic from the Upper Peninsula of Michigan. It gets a lot of local traffic, such as that of the people living in Florence who work in Iron City, but not so much of the through traffic. Both sections of the road, however, will have the same traffic conditions.

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CHAIRMAN HOWE: The next paper we have on the program is entitled "Factors Governing Stability in Asphaltic Limestone Pavements" and it will be read by Mr. J. H. Conzelman of the Alabama Rock Asphalt, Inc., at Birmingham, Alabama.

# Factors Governing Stability in Asphaltic Limestone Pavements

**By J. H. Conzelman, Birmingham, Ala.**
*Assistant General Manager, Alabama Rock Asphalt Company*

Resistance to displacement under traffic, or stability, is a well recognized feature of asphaltic limestone pavements. Examples are numerous of asphaltic limestone pavements which contain a considerable excess of bitumen as evidenced by an "alligatored" surface and which carry severe traffic without any evidence of displacement. While shoving or rutting have not been causes for concern to engineers laying these pavements the stability and shear strength tests are of exceptional value in studying and designing this type of asphalt mixture. Prior to the development of these tests there was no way of measuring the stiffness or rigidity of paving mixtures. Doubtless many asphaltic limestone pavements have much higher stability than they need safely to carry heavy traffic. While examination of old pavements shows no serious difficulties resulting from high stability or rigidity, except perhaps in isolated instances, and while the mixtures have been reasonably easy to rake and compress and the resulting pavements have been durable, the best design of rock asphalt mixture would be one that filled the voids in the crushed aggregate with as soft an asphalt as safely could be used.

## RESISTANCE OF ASPHALTIC LIMESTONE MIXTURES.

The usual asphaltic limestone pavement, considering only those asphaltic limestones produced in the United States, consists of a pulverized, bitumen-impregnated limestone and a suitable flux or added asphalt. The characteristics of the bitumen in the rock cannot be determined accurately with present laboratory methods. There is also no way of determining exactly how much of this bitumen combines with the added flux. The porous limestone is changed to some extent physically by extraction of the asphalt. It, therefore, is evident that a test on finished mixture that measures its stability is valuable especially in studying this type of pavement. Durability and stability are the most important requisites of an asphalt paving surface. A paving aggregate having high inherent stability allows the use of softer bitumen and a higher percentage of bitumen. The durability of an asphalt mixture should be increased; first, if the bitumen is of such consistency that after heating and mixing it still is soft enough to assure a long life in the pavement before the hardening that gradually takes place there kills its efficiency; second, if a sufficient quantity of bitumen can be used to assure filling the voids and coating the particles of aggregate generously.

Considerable investigation during the past few years has indicated safe values for shear strength and stability. If, by taking advantage of the high inherent stability of asphaltic limestone, we make its active bitumen soft enough and of sufficient quantity to assure long life and still not reduce stability below the danger point, we should have a most durable, satisfactory pavement. A comparison of resistance to shear of typical Alabama asphaltic limestone mixtures and high-stability, low-void sheet asphalt and asphaltic concrete is shown in the following tests made by the Chicago Paving Laboratory.

TABLE No. 1. RESULTS OF SHEAR STRENGTH TESTS ON VARIOUS ASPHALT MIXTURES

| MIXTURE | SIEVE ANALYSIS—RAW MATERIAL | | | | | | | | Voids Dry Agg. % | Required Bitumen % | Voids in Compressed Mixture % | Shear Strength 140° F. lbs. per sq. in. | Bitumen Mixture by Analysis | Penetration Added Asphalt | Asphalt Added to Rock Asphalt % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 200 | 80 | 40 | 10 | ⅜ | ⅝ | ¾ | 1¼ | | | | | | | |
| Alabama Asphaltic Limestone ........ | 13.7 | 10.3 | 15.8 | 41.1 | 19.1 | | | | 22.2 | 9.9 | 1.3 | 64.9 | 9.8 | 99 | 5.2 |
| Alabama Asphaltic Limestone .. .. . | 13.7 | 10.3 | 15.8 | 41.1 | 19.1 | | | | 22.2 | 9.9 | 1.4 | 53.8 | 10.6 | 83 | 5.8 |
| Sheet Asphalt....... | 24.3 | 18.2 | 35.8 | 21.7 | | | | | 17.9 | 7.8 | 4.2 | 51.4 | 7.8 | 61 | |
| Modified Topeka... | 14.2 | 18.4 | 20.5 | 15.6 | 11.1 | 20.2 | | | 15.7 | 6.8 | 3.5 | 44.5 | 6.8 | 61 | |
| Large Stone Asphaltic Concrete ......... | 8.9 | 11.8 | 15.8 | 10.3 | 0.4 | 14.2 | 27.2 | 12.2 | 13.0 | 5.5 | 3.1 | 38.2 | 5.5 | 61 | |

It will be noted from these results that voids in the asphaltic limestone dry aggregate were sufficiently high to allow the use of a satisfactory percentage of asphalt. Good compressibility and resistance to absorption are shown by the low percentage of voids in the compressed mixture. That variations encountered in the usual control of a paving plant will not reduce stability below the danger point is indicated by the second mixture which contains seven-tenths (0.7) per cent more bitumen than is required to fill the voids and still has a little higher shear strength than the low-void synthetic mixtures. Variations in stability of asphaltic limestone mixtures only can be secured by varying the characteristics and amount of active asphalt in the mix, by varying the fineness to which the asphaltic limestone is crushed or by adding a foreign aggregate to the mixture.

### Nature of the Asphaltic Cement.

The asphalt contained in the pores of both the Texas and the Alabama asphaltic limestone is hard. The penetration of that found in the Texas deposits is about 8 and that of the Alabama rock about 20. The bitumen content of the Texas rock as shipped is around 9 to 11 per cent, while the Alabama product contains from 4 to 6 per cent. Both of these materials, of course, must be fluxed to provide a film of bitumen around the aggregate that is soft enough to prevent cracking and is in sufficient quantity to bind the particles together. Probably the least understood factor in the construction of asphaltic limestone mixtures has been the active bitumen content. The minimum penetration that the bitumen in a mixture can have may be determined for any given flux, but how much of the native bitumen combines with the flux and, therefore, what the penetration of the active bitumen is cannot be determined. Since the stability of a mixture decreases as the penetration of the bitumen increases the stability test makes it possible to determine how soft a flux safely may be used. The quantity of asphalt in the mixture also affects the stability of the mixture. Too little bitumen results in a mixture that is hard to compress and, therefore, is not as stable or durable. Of course the use of bitumen in excess of that which is needed to fill the voids lowers the stability.

A study of the stability of Alabama asphaltic limestone mixtures is being made in which varying percentages of hard to extremely soft asphalt are added. These tests have not been completed but they indicate that with this material, safe stability, to carry the heaviest traffic, is secured when an added asphalt of 85 to 100 penetration is used in sufficient quantity for the total "recoverable" asphalt to fill the voids. By "recoverable" asphalt is meant the bitumen that can be extracted from the crusher-run rock asphalt plus the added bitumen. A portion of the native bitumen in the rock, usually about one per cent in the Alabama product, is contained in the larger particles of aggregate and is not recovered. A series of tests made by the Chicago Paving Laboratory show that asphaltic limestone mixtures are subject to the voidage theory of design. Mixtures containing one and one-half per cent less asphalt than was required to fill the voids showed good compressibility, as indicated by low voids in the compressed mixture, but looked lean. The use of more bitumen than was required resulted in lower shear strength than was secured on either the too lean or the correctly designed mixtures.

These results substantiate field experience where mixtures containing one per cent more bitumen than is necessary to fill the voids in the crusher-run material look too rich and are more difficult to rake.

### ASPHALTIC LIMESTONE AGGREGATE.

Most limestones have a greater affinity for asphalt than silicious materials have. To this quality, to some extent, possibly because the pores in an asphaltic limestone are filled with bitumen, may be attributed some of the unusual stability that can be developed with this material. To a far greater extent the high resistance to displacement is attributable to the porosity of the rock which results in a crushed material having a rough uneven surface, increased contact points and high frictional resistance. Even the very fine particles of the crushed material have this rugged surface, for the rock contains numerous minute pores. The part this porous aggregate plays in developing the stability of asphaltic limestone pavements is shown in a study of various aggregates made by the Chicago Paving Laboratory and included in a paper presented at the Sixth Annual Asphalt Paving Conference by Mr. Skidmore.

One of the aggregates used was a Texas asphaltic limestone from which the bitumen had been extracted. All mixtures were made with the same 200-mesh content and grading of material. An asphalt of 40 penetration was used with each mixture in sufficient quantity to fill the voids. The following shear strengths were obtained:

| | |
|---|---|
| Lake Michigan Sand | 51.5 lbs. per sq. in. |
| Kentucky Rock Mineral | 64.0 lbs. per sq. in. |
| Crushed Granite Sand | 84.0 lbs. per sq. in. |
| Asphaltic Limestone Mineral | 133.5 lbs. per sq. in. |

Another interesting feature of these tests was the fact that, while practically the same grading of each was used, the asphaltic limestone aggregate contained the highest voids and 1.1 per cent more bitumen was used with it than with the Lake Michigan and Kentucky sand mixes.

### GRADING THE ASPHALTIC LIMESTONE.

As for other types of mixture asphaltic limestone mixtures designed on the voidage theory develop higher resistance to shear or stability as voids in the aggregate or raw material decrease. Studies made by the Chicago Paving Laboratory show that a shear strength of well over 100 pounds per square inch can be secured by finer crushing of the rock. Shear strength and stability tests have been made on asphaltic limestone mixtures to which sand has been added to bring up sizes which seem, from our ideas of synthetic mixture grading, to be deficient. While the addition of sand in this manner often decreases the voids in the raw aggregate, such mixtures always have a lower shear strength than the straight crusher-run asphaltic limestone.

A limited number of tests indicate that reduction in shear strength is not serious when less than twenty (20) per cent of sand is used but is very marked for higher percentages. For example, on a crusher-run asphaltic limestone, to which 5.5 per cent of 100 penetration asphalt was added, the total recovered bitumen content being 10 per cent, a shear strength of 65 was obtained. A shear strength of only 41 was obtained on the same asphaltic limestone with 25 per cent of sheet asphalt sand added and the same percentage of bitumen used in the mixture. In the latter mix asphalt of 85 penetration was added instead of 100 penetration, to compensate for the smaller amount of native hard asphalt present. Some experiments also have been made with mixtures of crusher-run asphaltic limestone and slag and limestone screenings. The indications are that either slag or limestone screenings, when properly graded, can be added to an asphaltic limestone in amounts up to fifty (50) per cent of the total aggregate without seriously lowering the stability of the mixture.

### Conclusions Drawn From Tests.

(1) It may be stated that stability tests show asphaltic limestone capable of developing higher resistance to shear than other paving aggregates now used.

(2) This quality allows the use of a softer bitumen and a sufficient quantity of bitumen to assure maximum durability.

(3) That asphaltic limestone mixtures should be designed on the voidage theory and when so designed their stability can be increased or lowered by controlling the consistency and amount of active asphalt present.

(4) The stability of these mixtures can also be increased or lowered by a coarser or finer crushing of the rock, which increases or decreases voids in the aggregate.

(5) That unnecessarily high stability in an asphaltic limestone may also be lowered by the addition of sand to the mixture, though this practice would probably result in no increase in the durability of the resulting pavement.

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Chairman Howe: This paper should prove very beneficial to those interested in laying Alabama rock asphalt pavements. Are there any questions you wish to ask the author? Any discussion of the paper? I think this paper stands out in my mind in one respect. A few years ago you heard very little of the use of the stability test in a laboratory for the control of asphalt paving mixtures. I think today practically every progressive laboratory is using one of the several types of the stability test. I would like to see a paper at one of these meetings of the Association of Asphalt Paving Technologists comparing, through various ranges, the stability tests. I think there are four principal types.

The next paper is the "Preliminary Report on Investigation into Causes of Cracking in Sheet Asphalt" by Mr. F. J. Leduc of the Municipal Laboratory for Testing Materials at Montreal, Quebec, Canada.

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# Preliminary Report on Investigation into Causes of Cracking in Sheet Asphalt

**By F. J. Leduc, I. C., Montreal, Que., Can.**
*Chief, Laboratory for Testing Materials, City of Montreal*

At last year's annual meeting of the Association of Asphalt Paving Technologists, Mr. Henry L. Howe, chief engineer of the City of Rochester, N. Y., presented a very interesting report on "Deterioration of Asphalt Pavements from Natural Causes." A very elaborate work was presented, which was greatly appreciated by asphalt paving technologists. The method used by this author in his report was to classify the different causes of the deterioration of pavement, describe some of the characteristics of same and give remedies applicable so as to enable us to avoid those defects in our future asphaltic surfaces. In the report on some aspects of this problem which I have the honor to present to this meeting, the method applied is different and the work is more restricted in its scope. It is limited to cracking in our Montreal pavements.

### Method of Investigation Used.

The method we have used is that of a careful survey of the superficial appearance of the pavement. The cracks noticed are either sketched or photographed. Groups of those presenting similar characteristics then are formed to facilitate compilation and comparison. Of course, some groups are more complicated than others and show a combination of characteristics. At this stage in our work, which, by the way, is only started and is far from being completed, we may say that such group classification as I have indicated is possible in nearly all cases. As a next means to this investigation, the most likely causes for the appearance of each group of cracks will be assumed and the work, both at the laboratory or in the field, will be to ascertain if such hypotheses are well founded.

The primary object of this investigation is to ascertain the causes of cracking in some sections of our pavements, especially in new construction, and, as corollary, to discover the remedies to avoid same. As a secondary object, there is the preparation of graphs to assist in the control of our inspection and to give our plant inspectors an occupation during the winter months. We first had in mind limiting this work to the cracking that is due to temperature changes alone but we find now that it cannot be delimited so easily. Therefore, we find ourselves forced to face our problem in a broader way.

This investigation is urgent, we feel, because, since the change from a high-asphalt-content pavement to a lower one and from a relatively non-dense mix to a very dense one, the defect mostly to be anticipated in our climate is that of cracking. This, of course, is what we actually have found on our streets. Construction of our Montreal pavements well can be divided into three periods. The first period was that from 1900 to 1916, when our pavements, or at least those made by the city, were produced without scientific knowledge. The only requisite necessary was to concoct a hot, black, granular mass. Fortunately for the citizens, practically all of those pavements lasted reasonably well. This was during the slow-moving, horse-drawn traffic period.

### Observation of Cracks On Streets.

The second period was from 1916 to 1922, when an adequate control was established by competent asphalt authorities, headed by Mr. Charles A. Mullen, director of the paving department of the Milton Hersey Company, Limited. During those years cracking practically was unknown. A few streets, however, occasionally would shove. From the latter date until now, a denser mixture has been produced. A certain amount of cracking is noticeable, however, especially since all our streets lately have been opened to winter traffic and the surface of our pavements exposed, by the removal of snow, to temperatures as cold as 10 degrees below zero.

As stated before, the first step in our investigations was to make a survey of our pavements. Multiple reproduction of cracks with similar characteristics, but independent of the street, the time of construction, the builder, or the material used, were encountered. Because of this fact. photographs or sketches were made to facilitate a better comparison of these phenomena.

It is not to the point, we think, to say that the observations made were rather expected and had been observed before by others. Since the inductive method was to be used in our work, we first had to be impressed by the facts so as finally to reach the causes that produced the effects that were observed. It might be of some interest to show here a few specimens of the groups already isolated in this investigation, but, as this paper is only a preliminary report, it may be premature to do so, since all the data to justify us is not yet compiled. Nevertheless we already are in possession of some very typical groups.

### Apparatus Used in the Investigation.

After classifying some of the cracks into groups, it was imperative that we investigate the reasons for their occurrence. The actual conditions of the base and surface first had to be known. To ascertain the state of the foundation, cores were drilled with a six-inch Ingersoll-Rand Calyx core drill, and these cores were taken to our cement laboratory for study. This sampling was done either at the point of fracture, or in the immediate surroundings.

Our work now is well under way and will continue all winter, our regular inspection staff being employed on it, but it will be a considerable time before definite results are available. The asphalt mixtures, of course, are available with this method of sampling. The asphalt cores are put aside for examination during the slack periods in our laboratory. This study consists of the ordinary analysis, stability tests made by the Hubbard-Field method and cold tests on the original sample, or on remouldings or reproductions of same.

### Nature of the Cold Tests.

To make cold tests, the laboratory is equipped with a freezer, having a capacity of sixty-six cubic-feet, which can attain working temperatures as low as 20 degrees below zero. It is protected by an ante-room having a capacity of 110 cubic feet, with a minimum of 30 degrees above zero. Unfortunately this equipment has been in operation only a few days and no tests, as yet, have been completed. A definite method in connection with the cold tests has not yet been adopted. The writer will be very pleased to receive any suggestions as to the best method to be used in working this new equipment.

A tentative method is being followed for the few tests already started, and it is as follows: Asphaltic slabs, 12 inches by 24 inches, by 1½ inches thick, were made in the laboratory, laid in a wooden frame and compacted by our 300,000 pound hydraulic compression machine. The pressure per square inch, no doubt, will need to vary for different experiments. The slab produced then was left to cool in the mold, later being placed in the freezer or ante-room and subjected to different treatments such as freezing, thawing, immersion in water and the like. The wood mold was found to be not strong enough and it will be replaced by a steel one for future work.

It may be well to give here a few of the variable factors we consider studying in our winter experiments. Although the list is incomplete, we may mention a few of them, such as the different amounts of asphaltic cement, the penetration of same, the stone-dust filler, sand of different origin, the different base or lateral supports and such factors.

### NATURE OF THE FIELD TESTS.

To take advantage of the coming winter season, the laboratory already has laid different experimental pieces on some of our newly paved streets as a means of comparison for the laboratory mixtures which will be experimented upon next winter. These tests are under the control of one of our chemists, who has at his service the ordinary plant testing equipment and a one and one-half ton truck. He must take note of the condition of the asphalt surface and that of the base as they are prepared and laid. A twenty-five pound sample of each mix is retained for our investigations later in the laboratory. A few experimental patches already have been laid where the variables were as follows:

1°—Variation in the amount of asphaltic cement.
2°— " of amount of stone-dust filler.
3°— " " asphaltic cement and stone-dust.
4°— " " the heat of mixing.
5°—Introduction of foreign bodies into the mass; wet or dry wood, stone-dust, water, etc.
6°—Variation of the bond between curb and mixture, the binder and top, the base and binder, etc.

It was suggested by Mr. Charles A. Mullen that it would be proper to investigate the relation of asphalt to voids; that is, the density of the mix and what percentage of air space there is in the pavement mass. This may be included.

### BATCH CONTROL FOR TEMPERATURES.

In our field tests, we must know some of the conditions under which the mixture is made and the temperature of every batch entering into the experiment is considered a very important factor. It might be proper here to describe experiments that were made during the past summer in one of our city plants for the proper taking and recording of temperatures. This plant is an old model that was built for half the present capacity and, to get the latter output, heating of the drums has been so forced that it is little wonder that we have on our daily records many odd batches close to 500 degrees F. Of course, before this recording was arranged, we never heard of such high temperatures, the asphalt inspector never having reported them and the plant foreman, I presume, having no interest in advertising his mishaps. It is for this reason that a description of our temperature recording installation is given here at some length, especially because ageing of the asphalt cement through overheating probably is a cause of much of the cracking.

This control is not a new thing. At many plants in Europe it is done for every batch but, the mixing time being much greater than it is here, the problem is simpler, especially in view of the fact that an indicating pyrometer, instead of a recording one, has been and still is used in most of the European plants. It immediately was discovered that the asphalt thermocouples offered by the trade had too great a heat inertia or lag, and that a special type would have to be built since we had only one minute for our recording. The type found most satisfactory was one having the hot-point or welding left entirely exposed and the supporting tube for the wires made of fibre or wood, instead of steel. In this way, the necessary time of contact with the hot mass has been reduced to 45 seconds.

### SPECIAL CHART IS NECESSARY.

Connections are made to a recording instrument having twice the speed of the standard one, but even this increase is not sufficient. It should be twice as much as the one we now have. The ordinary chart used will give the temperature but not the time, since the speed of moving is changed. If both time and temperature are needed, a special chart will have to be designed. This we plan to do when our experiment is concluded.

MAIN STREET, GREENFIELD, MASS. BECAUSE OF THEIR REASONABLE COST, ASPHALT MACADAM PAVEMENTS, LIKE THE ABOVE, ARE ADMIRABLY ADAPTED TO USE IN THE SMALLER CITIES AS WELL AS THE LARGER ONES.

One drawback of our installation is that the needle registers every minute. In this way it might register a lower reading than the actual one but as this error is against us, it does not effect the argument which it may be necessary to start with our inspector or plant foreman on account of having temperatures that are too high. The best device would be a recording mechanism that will print only when the operator finds that he has the actual temperature of his batch. We have one now that keeps the needle from printing when no observations are made. This one allows us to space our loads on the chart, but it does not, at all times, indicate the highest temperature.

The recording alone is automatic. A man is required to insert the thermocouples in every batch. This has a decided advantage, since the operator becomes familiar with the appearance of the material and is able to notify the plant foreman of any change occurring in the process of mixing. Moreover, next to his recorder he has a panel with all the plant temperature instruments and, in that way, he is enabled to notify the stokers if temperatures get too high or too low.

The results obtained this year have been such that there is a possibility that next year's city specifications will require this control to be on every mixer in plants supplying material to the city. In this way, one of the main factors in obtaining a good mixture would be checked carefully and we no longer will have to depend upon a plant inspector's occasional observations to give us this valuable information. Our experience has been gained exclusively on sheet asphalt but, most likely, what is true of one mixture will be found in another.

### Premixing of the Aggregates.

In our investigation of cracking we have found many cases where, after a day or so, a piece of new road which had just been laid, showed cracks exactly as in a plaster wall when particles of lime have not been slaked properly in the process of making the mortar. A foreign body had expanded and broken the surface in different directions. These cracks usually are a few inches long, starting from an unit centre. When examining samples taken from such spots, we found that some of the stone-dust filler had agglomerated and when the pavement had contracted in the process of cooling, this lump had not contracted and had broken the top layer.

For many other reasons than avoiding occasional cracking in the finished surface, an intimate mixing of the cold stone-dust with the other aggregate has been advocated in the past. Different processes have been suggested and used. Unfortunately, in our plants, we do not have an ideal process. I look forward with deep interest to the success of the experiments promised last year by Mr. H. C. McClure, city engineer of Flint, Michigan, in his paper on "Needed Improvements in Paving Plant Equipment and Methods", presented to the Eighth Annual Asphalt Paving Conference, in which he states that "plans are now being made to add dust next year at the cold end of the dryer and to produce an all-hot, dry-mixed aggregate." This would be ideal, especially if compared with the process used in this district.

### Benefit of the Investigation.

Our process consists of weighing the sand into a weighing bin and then adding on top the proper amount of filler. Both are dumped into the mixer together but in this operation some dust easily escapes and pollutes the air. The operator, in self protection, simply opens the asphalt valve, with the result that no proper dry-mixing of dust and sand is made and the asphalt is not well distributed in the mass, since part of it congeals on the cold stone-dust. Even one minute of mixing will not improve entirely those conditions. This defect is exaggerated when the filler is damp. The influence of the improper introduction of the dust filler into the mass may be greater than expected. Of course, this factor is one of those which we are to study in our future work.

One of the secondary objects of this investigation is to control more easily and properly our inspection force. The general supervisor has to rely to a great degree upon the reports of his men. He may, of course, check up on the samples either at the plant or on the street, but this does not give the whole story of the pavement.

For example, if groups or "families" of cracks were well established and causes for the production were well ascertained, a time check by field results on this control would be easy. The supervisor would use the same language as his inspector. If checking-up on a pavement is carried out and the reports show that it presents a certain number of definite types of cracks attributed to different causes, such as overheating, improper mixing, poor lateral or base support, etc., then it would be easier to locate the responsible parties or the defects in practice. From such considerations of past work it would be easy to improve our inspection and our practice on future work. It is with these points in mind that the investigation is going on. Please remember that your comments are solicited.

CHAIRMAN HOWE: I believe Mr. H. C. McClure, director of public works at Flint, Michigan, is to open the discussion on this very interesting paper.

# A Discussion of the Causes of Cracking in Asphalt Surfaces

## By H. C. McClure, Flint, Mich.

*Director of Public Works, City of Flint*

Cracks in asphalt surfaces are unsightly. They increase the expense of maintenance and certainly must tend to shorten the life of the pavement. We believe that any study such as Mr. Leduc is making, is a step in just the right direction and, when carried along in a location where there is a plant and a well equipped laboratory side by side, it should lead to some very convincing conclusions. We have found that there is a tremendous advantage, in making studies for asphalt mixtures, in having the plant and laboratory at the same location. We have found that investigation of trouble within a very few minutes after the report has been made, and possible correction of it, have proved to be very valuable. Solutions have been effective at once, which would not have been possible with the laboratory and plant located at points more or less widely separated.

### EFFECT ON PAVEMENTS OF SNOW REMOVAL.

We have equipped our laboratory with what we believe to be modern laboratory equipment. In addition to the usual and standard asphalt testing apparatus, we have a Ro-tap for mechanical sand analysis and each and every sand analysis can be completed exactly as the ones previously made. The human element is eliminated absolutely. We have a Hubbard-Field stability machine for making comparative stability tests on the various mixtures used and proposed. We also have a Toledo special-purpose scale of 200-gram capacity. With this we can read directly the accumulated sand-analysis weights to a tenth of a gram. With this equipment we are able to make many more identical analyses in a very much more accurate manner than would otherwise be possible. It is our opinion that, in asphaltic mixtures, any experiments which depend to any degree on the human element for accuracy are likely to be very misleading and unreliable.

Mr. Leduc has mentioned in his paper one item, which we in the northern climates have to face and which we believe is one cause of pavement deterioration not experienced in places where extremely low temperatures are not encountered. He refers to the policy of removing the snow from our highways, which is now demanded by the automobile using public, and the fact that the exposure of the surface to extremely low temperatures gives rise to internal stress, because of extreme temperature changes, and, at the same time, subjects the surface to a heavy traffic pounding when it is in its most rigid and brittle condition. As an illustration of the effect of this, we have extremely low temperatures at times in northern Michigan but, when the ground is covered with the very heavy blanket of snow common in that territory, it is not infrequent to have very little, if any, frost in the ground and to have very much less frost penetration than we have in the southern part of the state. However, this condition of the uncovering of the pavements and exposing them to extreme temperatures, is something which must be met, since the automobile demands almost the same riding convenience in midwinter as in midsummer. Surfaces must now be designed with this added requirement in view. Mr. LeDuc's cold-test laboratory work will be watched with a good deal of interest.

Mr. LeDuc has referred to an experiment which we had planned to carry on in our work this year to an extensive degree. It is that of mixing our sand and dust through our drier and having a completely preheated and premixed fine aggregate ranging from dust to the largest allowable particles. We did carry this on with our equipment in a limited way and laid some of this mixture on the street. Owing to the fact that we were unable completely to rebuild our plant and provide proper hot storage bins, covered mixer and other necessary improvements, we were not able to carry it on to any great extent during this year. The mixture we did lay apparently gave a very satisfactory mix in a much shorter time than was possible with the usual process of dumping cold dust into the mixture just in advance of the asphalt cement.

### SEARCH FOR THE CAUSES OF CRACKING.

It is possible to get just as satisfactory results with a somewhat lower temperature and that in the end would result in a saving in cost. The pavement which was laid with this premixed, preheated aggregate is in excellent shape. No cracks whatever are shown in the section laid. We are planning to complete the rebuilding of our plant this winter and it is our intention to make a very extensive test of this preheated, premixed method during the coming season. We are confident from the experience we have had that the plan will work. If the plan is practical, we will be able to get more satisfactory mixtures in a shorter time and to cut the cost of mineral filler materially because it can be shipped loose and damp in open cars and can be secured at but little more than half of its present cost. In our opinion, the plan is not possible unless the plant is equipped with adequate dust collectors which are capable of collecting at least 95 per cent or more, of the 200-mesh and finer particles and adding them, in the same proportions as those in which they are removed in the drier, back into the mixture, just ahead of the pug mill.

We are anxious to know the causes of cracks and the remedy for them. We believe that our laboratory has found at least some of the contributing causes. Our present mixtures are designed on the assumption that the laboratory has found one of the primary causes. Two years ago at New Orleans, several papers pointed out the fact that too little study had been given to the real function of fillers and that from a further study of this might come better pavements. A number of years ago when slow-speed traffic, in volumes not approaching present day volumes, used the streets, the high-bitumen, low-dust mixtures were used in our location just as they were used elsewhere. These did not crack, except perhaps as base cracks, but with the approach of the heavy, rapidly-moving vehicles, these pavements began to shove and displace. The swing of the pendulum, regarding dust and mixtures, was too far to the other side. As a result, a great many yards of the low-bitumen, very-high-dust-content types were built.

### Cracking in Portland Cement Concrete Bases.

In these pavements, beginning at four or five years, we find that we have that type of cracking which covers an area generally extending over the street. There is no apparent general direction to the cracks for they seem to extend in any direction parallel to or at right angles to each other. In many cases they do not even follow the foundation construction joints. Samples from these pavements indicate a low bitumen and a very high dust content. These samples, reprepared and compressed in our laboratory, show excessively high stabilities ranging between forty-five and fifty-five hundred (5,500) pounds. Laboratory stabilities on our satisfactory mixtures run around three thousand (3,000) pounds. Samples from various streets, showing this same sort of cracking, indicate almost identical results as to analyses and reconstructed stabilities. It is the theory of our laboratory that this low-bitumen and high-dust combination is at least one cause of cracking. It is our chemist's opinion that the structure is so dense that it cannot work and knead itself under traffic and, as a result, is not able to withstand the traffic and temperature stresses.

Practically all of our pavements are built on concrete foundations which must have construction joints at the mid-day and end-of-the-day periods. In practically every one of these cases, we get the across-the-road crack which invariably shows up after a winter exposure. During the past three or four years this is practically the only kind of cracking with which we have had to deal. We are planning to experiment with the elimination of this sort of crack during the coming year. We propose to build every construction joint by using a vertical form to get a square butt joint and to mark the location of this joint plainly on the curb. We propose to cover this joint with a strip of sheet metal from two to three inches in width and then to cover metal and base for a distance of several inches on each side with a heavy burlap mopped into place with a suitable asphalt. We are hopeful that the treatment in some cases will eliminate the "pull" on the asphalt surface at this one particular point, and will spread this "pull" over a sufficient area so that the cracks will be eliminated or minimized. We do not believe that the width at which we are making the "pull-joint" will result in a hump or ridge under traffic, due to the fact that the base is somewhat smoother at this point than it is over the general area. If the plan reduces the cracking to any extent we will install regular steel center-joints at fifty to seventy-five-foot intervals in the daily runs.

We are specifying in our asphalt requirements that we maintain a ductility, at 39 degrees F., of not less than 5 centimeters, pulled at the rate of 5 c.m. per minute. We are hopeful that this low-temperature ductility, which we get in our asphaltic cement, in some measure still will be present in the asphaltic mixtures and that it will be able to stretch the top over a construction joint rather than rupture it as it does now. We are also planning to extend the use of "black base" and we know that the kind of cracks which now follow the concrete base cracks will be eliminated. We had another case of cracking this year, due to an equipment accident, which we believe indicates something that may also cause cracks, even when the mixture may be satisfactory. The hoisting mechanism on one of our trucks broke down and it was necessary to send a second load from the plant after working hours. This occurred just about dusk.

### MEASURED QUANTITIES REPLACE THOSE BY WEIGHT.

The next morning this particular section was fairly well covered with short cracks ranging from three to eight or nine inches long. They extended almost over the entire area. Analyses indicated the proper mixture, or at least one that was close enough to the mixture which had been maintained up to that point, and eliminated the question of an improper mixture as the cause of the cracking. The specific gravity of samples cut from this section, however, indicated a much lower specific gravity than adjacent sections which had properly closed. It was the opinion of the superintendent and the laboratory men that, because of improper rolling, very poor compression had been obtained. The adjoining area, laid with almost identical mixtures and laid during daylight and under proper working conditions, closed perfectly and showed a density considerably greater. We believe, therefore, that improper street control is another possible cause for surface cracking in an otherwise proper mixture.

Following the laboratory experiments, which indicate that mineral filler quantities are most important, we have made some rather radical changes in design and have evaluated all of our asphalt top materials on a volume basis. Instead of taking a weighed quantity of mineral filler, we are taking a measured quantity of this material. We are also reducing the laboratory investigations to a measured quantity of sands, because we have found wide differences in the weights of sand materials as well. It might not appear at first glance that the weights of two mineral fillers or sands would amount to a great deal but we believe that you will be more than surprised if you follow the volume and weight comparison through. We have adopted the volume method of comparison for the reason that, first, we are, in effect, selling our pavements to the public on a volume basis, and second, we have found that the use of equal volumes, regardless of the weights, gives much more uniform mixtures. It is the theory of our laboratory that, regardless of the particular makeup of the last individual particle, it will occupy just so much space. It is the size and not the weight of that last particular particle that governs.

Our asphalt sand this year is weighing only 105½ to 106 pounds per cubic foot, as against 113 to 115 in other years. Our use of silica dust has been cut down in weight very materially from our use of limestone because of the big difference in the unit weight of these two materials. Because of our belief that mineral fillers cause more trouble than ordinarily is thought, our laboratory also has followed through with experiments as to satisfactory plant mixtures and has carried the studies on mineral fillers still further. We have practically eliminated from our specification for fillers the single phrase "75 per cent passing a 200-mesh screen," because we believe that this phrase is entirely misleading.

We have found, in our experiments with a wide variety of silica, limestone dust, marble dust, slate dust and other forms of mineral fillers, that there is a wide variation in the grading of these materials. It is just as great as it is in the grading of sands and the coarser particles, We have also found, in a series of experiments by using identical weights of sand and asphalt cement and identical weights of these materials, that certain of the fillers produce greater stabilities than others. We have found by using identical weights of sand and asphalt cement, and identical volumes of the different fillers, that certain fillers give better mixtures than others. A further study indicates that those which have given the best stabilities and the most satisfactory mixtures, are those which not only pass the 200-mesh sieve, but include a large percentage that pass the 325 and 400-mesh sieves as well. Under the microscope these show a possible further grading, if finer screens were possible. We have found that those materials, which apparently are produced by air separation methods, and which show an abrupt falling off in the smaller sizes below the 200 mesh, give very much less satisfactory mixtures and results than those which carry the grading to the finer and finer sizes. It is not strange that the most satisfactory and most uniform mixtures give the fewest cracks.

## Satisfactory Mixture is First Essential.

It is the theory of our laboratory that a satisfactory mixture must be secured to eliminate future troubles and defects. A mixture satisfactory from the standpoint of plant handling and laboratory stability is very likely to give satisfaction in the street manipulation and rolling. Such a mixture can be counted upon to give more satisfactory results than one which does not show up as well in the laboratory or plant and on the street. It is our belief that the prevention of cracks in a great many cases can be accomplished by more rigid and continuous laboratory control and analyses of materials and procedure. A mixture which does not show up well in the laboratory or work well on the street is likely to give future trouble.

It also is the theory of our laboratory that a large part of our crack elimination is due to the fact that we are using mineral fillers which show a very uniform, smooth grading curve from 200 mesh down through the 300 and 400-screen sizes and finer particles. We believe that mineral fillers (incorrectly called "asphalt fillers") are underrated as to their importance in making or preventing cracking, resulting in maintenance and deterioration of asphalt paving jobs. We are hopeful that the elimination of cracks will be possible and we are offering our experiences to the conference for whatever value they may have.

## DISCUSSION.

Chairman Howe: I am going to ask Mr. W. C. Carlisle if he cares to discuss this paper.

Mr. W. C. Carlisle, Toledo, Ohio: I would like to offer one or two observations. Mr. McClure has referred to the analysis of the mineral dust as pointing out responsibility for the cracking. I thought, in view of the number of pavements that have been laid for the last two or three years, that I have had a rather good idea about the efficiency of fillers for asphalt pavements. I think possibly one of the most fertile sources of inefficiency, perhaps, is the overweighing of sand at the plants that are weighing sand and dust in the same hopper. The overdraft of sand, of course, is not so important but an underweight of mineral dust is, and, instead of drawing a predetermined and desired weight of mineral dust, it is materially underdrawn. A number of these cases show a very low 200-mesh or a very low 100-mesh. We have also found in some respects that there is a tendency to put in two sands wherever coarse sand is predominating, and that these particular pavements have developed breaks and disintegration, showing that the mixture unquestionably requires a certain proportion of the 200-mesh of the finer size to function economically in bringing the asphalt to the surface in order to get a good seal coat.

My conclusions are that a great deal of progress will be made towards the elimination of cracks by getting our plants under control so that there will not be too much sand and too little asphalt. I think this solution lies largely in the dial scales. We readily can see where frequently an operator at a plant has little advance notice of the actual balancing of the weighing beam. Sand goes pretty fast and when the beam on the scale goes down, probably fifty pounds more have run in before the gate closes, whereas if he has a dial scale he has an opportunity to watch it, and while that does not stop the overdraft of sand entirely, if he has an overdraft he has a chance to correct it by a corresponding amount of dust. I think that by putting the weighing operation under closer control we will go further in eliminating cracks than anything else we can do. In the majority of cases the mixture is out of balance in the proportion of sand to dust.

Chairman Howe: I think Mr. Carlisle's remarks upon the use of the dial scale are correct. In our city we did away with our beam scales and put in dial scales with a great deal of satisfaction, not only in the degree of control, which has improved, but as an accurate means of checking our asphalt received from the tank cars and the asphalt used, or supposed to be used, in the mixture. They have been very satisfactory, I understand. Is there any further discussion of this paper?

Mr. Prevost Hubbard: Mr. Chairman, I should like to ask Mr. McClure a question to clear up a possible misunderstanding that I may have reached regarding one of his remarks. In connection with the volume proportioning of aggregates, I can readily appreciate the significance of the volume relationship as expressed by differences in specific gravity but do I understand that he recommends the use of volume proportions in actual plant operation?

MR. McCLURE: In buying our materials we require a price per ton because that is the way we have to buy it from the railroad shippers. However, we take measured quantities of the various sand and mineral fillers upon which prices are submitted and evaluate them, taking a number of weights of those materials on compacted volumes of known dimensions. Then from the price per ton and the volume of the compacted quantities, we evaluate them on a volume basis. In other words, we can afford to pay more for the light-weight sand of 105 pounds per cubic foot than we can for the 115-pound sand because we get more volume. Volume really is what we are after. In the plant, of course, we have to transfer this back to a dial scale reading which to the operator is a weight but to us is a volume.

CHAIRMAN HOWE: The next and last feature on the program is the "Report of the Committee on Pavement Guarantees," to be presented by the Chairman, Mr. Roger L. Morrison of the University of Michigan at Ann Arbor, Mich. This paper has been sent to us to be read. Being a member of the committee I will read the paper, Mr. Morrison being unable to be present. I will ask Mr. Hubbard, our past president, to take the chair while I am reading it. Because it is submitted to bring out discussion this report will not be adopted. It simply is submitted in a tentative form by the committee.

# Report of the Committee on Pavement Guarantees

### By Roger L. Morrison, Ann Arbor, Mich.

*Chairman*

In the early days of the asphalt paving industry comparatively little was known as to the various factors contributing to the success or failure of such pavements, and specifications were very meager, if used at all. Under these circumstances practically the only insurance available to a municipality was a maintenance guarantee given by the contractor. The situation was well expressed when, in rendering a decision in Trenton, New Jersey, in 1898, the court said: "The quality of the pavement cannot well be ascertained—without the test of time. It is therefore reasonable that those who lay such pavement should submit it to this test in order to insure its goodness." That pavement guarantees were not entirely satisfactory, even at that time, is indicated by an editorial writer in the *Engineering Record* of July 23, 1898, who said, in commenting upon the above decision: "The guarantee clauses of paving contracts are the source of endless litigation."

## THE SITUATION AT THE PRESENT TIME.

In 1901, George W. Tillson, in an article on guarantees, said that there was a question as to their purpose and asked if the purpose was (a) to protect the city against decay of a perishable material, or (b) against poor workmanship and material, the nature of which was not discoverable in a short period, or (c) to provide the city with a pavement absolutely free of cost during the guarantee period. His conclusion was that it was to cover item (b) and was necessary because the asphalt might be burned and various other harmful things might happen, unknown to the engineer. During the three decades which have passed since the above comments were made the theory and practice of asphalt paving have become better understood by all concerned. Specifications have become more definite and complete, inspection methods have greatly improved and the control of design, materials and construction has passed almost entirely from the contractor to the engineer.

In order to determine the present situation in regard to pavement guarantees the specifications of two technical associations, three consulting laboratories, forty-eight state highway departments, and ninety-seven cities were examined. The guarantee provisions of these specifications are as follows:

### *Technical Associations.*

Asphalt Institute

None

American Society for Municipal Improvements

Has an optional maintenance guarantee clause, period not stated. This clause specifies condition at end of guarantee period.

### *Consulting Laboratories*

None of the specifications includes a guarantee provision.

### *State Highway Departments*

New Jersey appears to be the only state regularly requiring a maintenance guarantee. The guarantee period is one year and covers "all work performed or material furnished that was not performed or furnished according to contract or defects which have become apparent since being replaced." The engineer is the judge as to the necessity of replacements. (1930 specifications, page 10).

Iowa has a state law governing street improvements in cities and towns which provides that all contracts for the construction or repair of street improvements (except graveling, oiling, chloriding, or repairs other than reconstruction of resurfacing) shall contain a provision obligating the contractor or his bondsmen, from the time of acceptance by the city, to keep in good repair such street improvement for not less than four years. The State Highway Commission's "Typical Specifications for Paving Projects on Extensions of Primary Roads Within Cities and Towns" conform to this law but they do not apply to the highways of the state and no guarantee otherwise is required by the State Highway Commission.

### *U. S. Bureau of Public Roads.*

The Bureau does not require or permit maintenance guarantees. On Federal aid work it cannot participate in any maintenance charge and therefore a deduction has to be made on all Federal aid projects approved for New Jersey.

### *Cities.*

Of ninety-seven cities in forty-two states, the District of Columbia and four Provinces of Canada:

33 call for a 5 year guarantee
1 “ “ “ 4 “ “
4 “ “ “ 3 “ “
3 “ “ “ 2 “ “
3 “ “ “ 1 “ “
1 “ “ “ 1 “ “ (or 3 years at extra cost)
2 “ “ “ 6 months guarantee
17 “ “ “ guarantee. Period not given. (General clauses not at hand).
3 “ “ “ letting with or without guarantee.
30 “ “ “ no guarantee.

Summarizing: Sixty-four cities require some form of guarantee, three provide for letting contracts either with or without guarantee and thirty require no guarantee.

### Advantages of Guarantees.

(1) The main object of pavement guarantees is to insure the city that the contractor will repair any deterioration due to defects in materials or workmanship which may have escaped notice during construction. The results of such defects may not be apparent for several years. (2) A guarantee furnishes a pavement entirely free from cost during the guarantee period. (3) A guarantee protects the city against the failure, from any cause or at least from any cause within the control of the contractor, of a new and untried type of pavement promoted by the contractor. (4) A guarantee may be desirable when the specifications and (or) inspection are inadequate. (5) A guarantee may be desirable if there are no adequate maintenance facilities available to the city. The above statements are true in theory though somewhat questionable in practice.

### Disadvantages of Guarantees.

A disadvantage to one party to a contract is apt to be, sooner or later, a disadvantage to the other party but the following objections are classified as they appear most directly to the city or to the contractor.

(A) From the standpoint of the city:

(1) A pavement guarantee forces the abutting, or adjacent, property owners to pay the cost of maintenance during the period of the guarantee in addition to the original cost of the pavement. Courts have decided, in several cases, that a pavement guarantee is not a maintenance provision, if the period is limited to five years, but it is obvious that most guarantee clauses, if strictly enforced, cover repairs due to ordinary wear and tear as well as those due to defective construction. (2) The price of the pavement is increased by the amount of the contractor's estimate of the cost of repairs, plus the cost of the bond, thus often making the repairs more expensive than if they were made by the city. (3) It frequently is difficult, if not impossible, to get the contractor to make repairs when they are needed, the pavement being in a bad, and sometimes a dangerous, condition in the meantime. (4) Disputes about repairs often result in extended litigation which costs the city more than the repairs would cost and delays the needed repairs. (5) Many cases are on record where it has been impossible to enforce the guarantee clause even through the courts and the city has had to pay for the repairs in

the end, after suffering the delay, inconvenience and expense of a law suit. (6) It is possible that, under light traffic, defects of materials or workmanship may not be apparent during the first five years, though causing trouble later under heavier traffic. (7) In many cases the repairs needed during the first five years are negligible so that the extra cost of the guarantee in such cases is money wasted.

(B) From the standpoint of the contractor:

(1) It is unfair to have a pavement constructed in accordance with the engineer's specifications, covering every detail of workmanship and materials, and then force the contractor to guarantee the results. In other words, it is unfair to make him guarantee the soundness of the engineer's ideas as well as his own work. This especially is true when the specifications are contrary to the contractor's judgment as to what will produce the best results. Orders of the engineer are often carried out over the protest of the contractor, so that the latter, in guaranteeing the pavement, is forced to back the engineer's judgment against his own. (2) Under present conditions the contractor is allowed little, if any, opportunity to exercise his own judgment, so that he should not be held responsible for results in the same way that contractors were when they built pavements practically according to their own ideas. (3) Guarantees are not required on most other types of construction. (4) The contractor must make a liberal estimate of maintenance costs and raise his price accordingly, thus decreasing his chances of getting the contract, or he must gamble upon the chance of not being called upon for much repair work. (5) Most guarantee clauses are so worded as to include

WACKER DRIVE, NORTHEAST FROM STATE STREET, CHICAGO, ILL. THIS CELEBRATED THOROUGHFARE, THE FIRST DOUBLE-DECK, FAST-TRAFFIC STREET TO BE CONSTRUCTED IN THIS COUNTRY, IS PAVED WITH ASPHALT AND CARRIES A VERY HEAVY TRAFFIC.

repairs due to ordinary wear and tear as well as to construction defects and, if rigidly enforced as to the condition of the pavement at the end of the guarantee period, would often work a hardship upon the contractor. (6) The contractor must gamble upon the degree of strictness with which the engineer will enforce the guarantee clause, and even if he knows what the present engineers' attitude will be, he must gamble upon the chances of a change in administration before the expiration of the guarantee. (7) The contractor must gamble upon the chances of damage from causes over which he has no control, such as the elements, the back-filling of trenches, drainage conditions and unforeseen changes in traffic conditions. (8) If the contractor raises his price sufficiently to cover all of these hazards and is successful in getting the contract, it is evident that, as a rule, the extra cost of the guarantee, to the city, will be much greater than would be the cost of making the repairs in the absence of a guarantee.

## CONCLUSIONS AND RECOMMENDATIONS.

The contractor should be held responsible in the contract, with no definite time limit, for the repairs necessary to correct any defect in the pavement caused by non-compliance with the specifications by the contractor, unless such non-compliance occurred with the written approval of the engineer. A thoroughly responsible contractor will make good such defects without a specific guarantee and an irresponsible or dishonest contractor usually cannot be forced to make repairs, except through court action, if at all, even though he may have filed a guarantee protected by a surety company bond. Carefully drawn specifications, competent inspection and complete records will reduce possible faults of the contractor to a minimum, and practically will fix responsibility for any faults which possibly may escape notice during construction. While a guarantee may be justified in the case of a new pavement type, or where the specifications, inspection or maintenance facilities of the city are inadequate, it is the opinion of your committee that, under all ordinary conditions, the greatest economy and the fairest treatment to all concerned will result if the specifications are so drawn that they will be clear and complete; if competent, conscientious and fair-minded inspectors are employed and if the engineer assumes responsibility for the work which he has designed and the construction of which has been entirely under this control. Under such conditions, we recommend the elimination of pavement guarantees.

Respectfully submitted,

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| R. L. Morrison, Chairman | George W. Porter |
| Manley Osgood | Malcolm H. Ulman |
| George H. Perkins | Henry L. Howe (not voting). |

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MR. HOWE: I might explain that I did not vote on this because, through pressure of other work, I did not have an opportunity to work with the committee in drawing up this report. In view of that fact, I spent a little time this morning drawing up a minority report which I will be glad to present if the association wishes it.

CHAIRMAN HUBBARD: We would be glad to hear it.

# Minority Report from the Committee on Pavement Guarantees

**By Henry L. Howe, Rochester, N. Y.**

*Member of the Committee on Pavement Guarantees*

This committee, under the able leadership of its chairman, Prof. R. L. Morrison, has given this subject of pavement guarantees very careful and thorough study and has reached conclusions which, in an ideal world, none of us, I believe, seriously can question. However, we must always approach an ideal by practical transitional stages, depending on the average of figures of all parties concerned in the transaction.

It was not many years ago that guarantee periods of ten or more years were required for city pavements. Today, however, I fail to find, in the table of guarantee periods for various cities as compiled by Prof. Morrison, any guarantee period of more than five years' time. It would seem then that our cities, over a long period of years, have been approaching the ideals set up by the committee as to quality of specification, adequacy of inspection and complete control of pavement construction by the engineer so that he should assume full responsibility for the quality and character of the work. The committee's report, however, does not seem to recognize the necessary requirements on the part of the contractor, the contractor's forces, the material supply men and political control and interference, all of which must be given equal consideration with the forces on the other side of the contract in order to reach the ideal state the committee has set up in its conclusions.

## Elimination of Guarantees Slightly Presumptuous.

Let us consider for a moment the present situation as to the use of pavement guarantees in our cities. The tables of the report show that under present conditions sixty-four cities out of ninety-seven upon which data could be obtained, or 65 per cent of the cities studied, still require some form of pavement guarantee. This data further shows that more than half of these cities require a guarantee period of five years, while less than one-third have no form of pavement guarantees. This table further shows that, as a rule, the older, larger cities in the country still require a guarantee. Is it not fair to assume that our larger cities have as good, if not superior, legal and engineering talent as our smaller cities, all based on years of actual experience? This also, I believe, is true as to the efficiency of inspection, quality of engineering and specifications, maintenance facilities, etc.

Based upon this data alone, I feel, it would have been slightly presumptuous on the part of our committee to recommend immediate elimination of all pavement guarantees. I do not think, however, that the conclusions of the committee should be so interpreted, as the committee ends its report by saying "under such conditions" (almost ideal conditions) "we recommend the elimination of pavement guarantees." The committee has outlined some of the advantages in favor of the guarantee but it weakens the force of these advantages by saying "the above statements are true in theory though somewhat questionable in practice." In general, I do not think these statements are questionable in practice.

Other advantages for having a pavement guarantee might be cited, as follows: A guarantee gives the contractor a financial interest in laying a pavement that will stand up under traffic over a period of years instead of a period which will be only sufficiently satisfactory to obtain his final estimate under his contract. A guarantee, when such guarantee requires the holding back of reserves to be paid back to the contractor with interest at a stated period or at the ends of the guarantee period, makes it difficult and unwise for an incompetent or "fly-by-night" type of contractor to come in and underbid the more competent, experienced and financially and morally responsible contractors in a city. In this manner a guarantee is an advantage both to the city and a competent contractor.

Let us consider the disadvantage of a guarantee, as set up by this committee, which is, first, that a guarantee forces the abutting property to pay for the cost of maintenance during the period of guarantee. Then, if the committee's second statement of disadvantages from the standpoint of the city is true,—that is, that the price of the pavement is covered by the contractor's estimate of the cost of repairs,—then the abutting property owner must carry a part or the whole of such cost of the estimated maintenance for the guarantee period. However, I believe most of us will admit that a standard type of pavement (the committee does not seem to question the possibility that a guarantee may be justified in the case of a new and patented type of pavement), if properly designed for the conditions, should have very little if any maintenance cost during its early life,—that is, during its guarantee periods. Consequently, outside of the bond, if required, it is very doubtful in my mind that the contractor does increase his bid possibly by more than enough to cover the cost of the bond premiums, slight loss of interest or profit on his guarantee money, if retained, and possibly a very slight cost for the filling of joints, cracks, etc., which may have to be closed during the period of the guarantee.

### CITY-FORCE REPAIRS MAY BE ECONOMICAL.

It is doubtful also that, as stated by the committee, the cost of such repairs are more expensive when made by the contractor than if they were made by the city. The well established contractor fills the permanent cracks at odd times when it is necessary to keep his year-round forces busy. If a guarantee money retention is made by the city, as should be done under a guarantee type of contract, it is not difficult to get the contractor to make these minor repairs and it should not cause the pavement to be left in a dangerous condition, if the contractor refuses or fails to make repairs, since a well drawn guarantee clause permits the city to step in and make such repairs with its own forces and to collect the costs out of the money retained. There always will be disputes and litigation over the cost of repairs or the reconstruction of defective pavements and I cannot believe that the elimination of a properly drawn guarantee claim will add to such disputes at the disadvantage at least of the taxpayer, or that such a guarantee clause will weaken the case on the part of the city.

As said before, the committee does not seek to question the advisability of requiring a guarantee in case of a new pavement type. Is it not

Bryant Street at Delaware Avenue, Buffalo, N. Y. This Beautiful Residential Street is Paved With a Sheet Asphalt Surface on an Asphaltic Base. Total Maintenance Cost, 1881 to 1921, $1.65 per Square Yard, or .041 Cents per Square Yard, per Year.

rather inconsistent then to argue that it is unfair to the contractor to be required to guarantee his work when constructed under standard forms of specifications, which, if properly complied with, have proven again and again that they have resulted in a satisfactory pavement requiring little if any expense for repairs during the usual guarantee periods. Under such proven types of specifications why should a contractor, plant foreman or asphalt mixer-man be allowed to use his unrestrained judgment as to the proportions and character of materials to be used in an asphalt mixture as against the judgment of technologists in our laboratories? Such judgment is apt to lead to the use of too much collector dust in place of properly ground filler or the use of materials readily available, regardless of their suitability. Such difficulties are common to all our testing and construction engineers. Under our present city conditions any slight additional cost required by a properly drawn guarantee clause is well worth the price. In conclusion then, I subscribe to the report of the committee only as an ideal that we must all work for.

Henry L. Howe,
Member of Committee on Pavement Guarantees.

## DISCUSSION.

Chairman Hubbard: Gentlemen, you have heard the original report and you have also heard the minority report presented by Mr. Howe. There are certainly two sides to this question. The pros and cons have been brought forward and discussed but I believe there are some of you here who may wish to add to this discussion. I feel sure that the committee will welcome any additions you may care to make. The report is open for discussion.

Mr. H. D. Smelser, St. Charles, Mo.: We find in our city that the psychological effect of a guarantee often helps to build improvements. In the six and a half years that I have been with the city not once has a contractor had to come back on the job and do any work after it was perfected. However, under our laws property owners have a right to bring remonstrances in order to kill the proposed improvement and by reminding the property owners that a guarantee bond is required to protect the city for one year (we require a bond for one year's time), it often helps us to put through an improvement that possibly we might not be able to put through without this assurance to the property owners.

Chairman Hubbard: Any further discussion? If not, I will turn the meeting over to Mr. Howe again to close the session. First I should like to make an announcement to the effect that there has been a miscarriage in connection with films which were supposed to be shown immediately after this meeting. The films were shipped but they have failed to arrive, and, therefore, it will be impossible to show them. I regret very much that this is so.

Chairman Howe: If there is no further discussion, we will now bring the meeting to a close.

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# MEMORANDA

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